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**ABSTRACT:** *The effect of environment on the distribution of plants is illustrated by a map showing the major types of vegetation on the North American continent. The vegetational units are controlled by climate, but the vegetation also reacts upon the climate. Extensive studies of Tertiary floras in the western United States by W. R. Chaney, D. I. Axelrod, and other authors show that the floras migrated and became more varied in response to climatic changes. These changes in the Tertiary floras are shown by fossil pollen and spores as well as by plant macrofossils.*

## **Tertiary spores and pollen related to paleoclimates and stratigraphy of California**

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### **INTRODUCTION**

The use of fossil plant spores and pollen brings a powerful new tool into geologic age-dating and stratigraphic correlation. The significant difference between these and the aquatic microfossils commonly used for zoning sedimentary deposits is that the pollen and spores are derived from sources outside the area of deposition. The terrestrial habitats of the parent plants are subjected to a different set of environmental conditions. Variations in these conditions over the land surfaces affect the geographic distribution of the plants and, in turn, the stratigraphic distribution of the fossil spores and pollen. For correct interpretations of the stratigraphic distribution of these plant microfossils, the geographic distribution of the parent plants at the time of deposition must be known.

### **MODERN NORTH AMERICAN FLORAS**

The effect of environment on the present-day distribution of plants is illustrated in text-figure 1, a map adapted from Transeau, Sampson and Tiffany (1940), showing the major types of vegetation on the North American continent. The vegetational units, termed climaxes or formations, are controlled by climate (Weaver and Clements, 1938, p. 479). (Vegetation formations are not to be confused with rock units.) Each climax is a direct result of the climate. However, the vegetation in turn reacts on and alters the climate. So intimate is the relationship between the two that

vegetation may be regarded as a better measure of climate than either human response or physical measurement.

In the arctic regions and above timberline in the high mountains is the tundra, characterized by low, dwarfed and often matted vegetation that includes a high proportion of grasses and sedges. The environmental conditions are severe, with relatively low temperatures, drying winds, and a short growing-season.

South of the arctic tundra lies the boreal coniferous forest, stretching in a broad belt from Alaska to Newfoundland. The climate is less rigorous than that of the tundra, but it is still very severe, with long, cold winters. The air is relatively dry, and the snowfall is not excessive. However, the ground is snow-covered and frozen for nearly three-fourths of the year, and the subsoil is more or less permanently filled with frost. On the higher mountains of the Appalachian system, the boreal forest extends south to North Carolina.

In the region around the Great Lakes and eastward to Nova Scotia, the boreal forest grades into the deciduous forest that covers much of the eastern United States. The climate in the area occupied by the deciduous hardwood forests is temperate, with distinct summer and winter seasons. All parts of the area are subject to frost.

On the coastal plain, extending from New Jersey into Florida and along the Gulf Coast to Texas, are the



TEXT-FIGURE 1

MAJOR VEGETATION TYPES OF NORTH AMERICA  
(Adapted from Transeau, Sampson and Tiffany.)



southeastern evergreen forests. Coniferous forests have replaced the hardwoods because the pines can survive the fires that periodically sweep through the grass ground-cover during the dry season.

The grassland is the most extensive vegetation climax on the North American continent. Its range, broken only by wooded stream- and river-valleys and isolated highlands, extends from northern Saskatchewan and Alberta to Texas, and from Minnesota and Iowa to the Rocky Mountains. In the western mountains, smaller grassland areas may be found from central British Columbia to the highlands of Mexico. The climate of the grasslands is characterized by a more or less extended dry period during the warm or growing season.

Along the Pacific side of the continent, from Alaska to Central America, the complex system of mountain ranges, valleys, basins, and plateaus has produced an equally complex climatic system. The climates of these mountain and intermountain areas are in equilibrium with the vegetation, which varies from desert to dense coniferous forests, grasslands, and tundra.

The tropical vegetation of southern Mexico and Central America is not influenced greatly by temperature. Moisture, which is influenced by topography, exposure, and seasonal distribution, is the main controlling factor; and wet and dry tropical forests are the major vegetation types of the lower latitudes.

The smaller subdivisions of the vegetation cannot be shown on a small map. The variation in the natural vegetation of the United States is shown in greater detail by Shantz and Zon (1924). This vegetation is the source of the pollen and spores now being deposited, along with other sediments, in and around the continental United States. If the counterpart of this map could be constructed for any desired instant in geologic history, it would be the basis for correlating the sedimentary rocks that were deposited at that time. Correlations over wide ranges of latitude must be based on dissimilar floras that are contemporary, instead of on similar floras. Cosmopolitan floras did not exist during Tertiary time. Where similar floras have been recognized over wide ranges of latitude, a time difference has also been apparent (Chaney, 1949).

#### TERTIARY FLORAS AND CLIMATES

The last great evolutionary surge in the plant world occurred during the Cretaceous. During this period, the angiosperms or flowering plants became the dominant elements in the flora. There is also evidence, from the remains of Cretaceous floras, that the Arctic was probably the original center of dispersal of modern

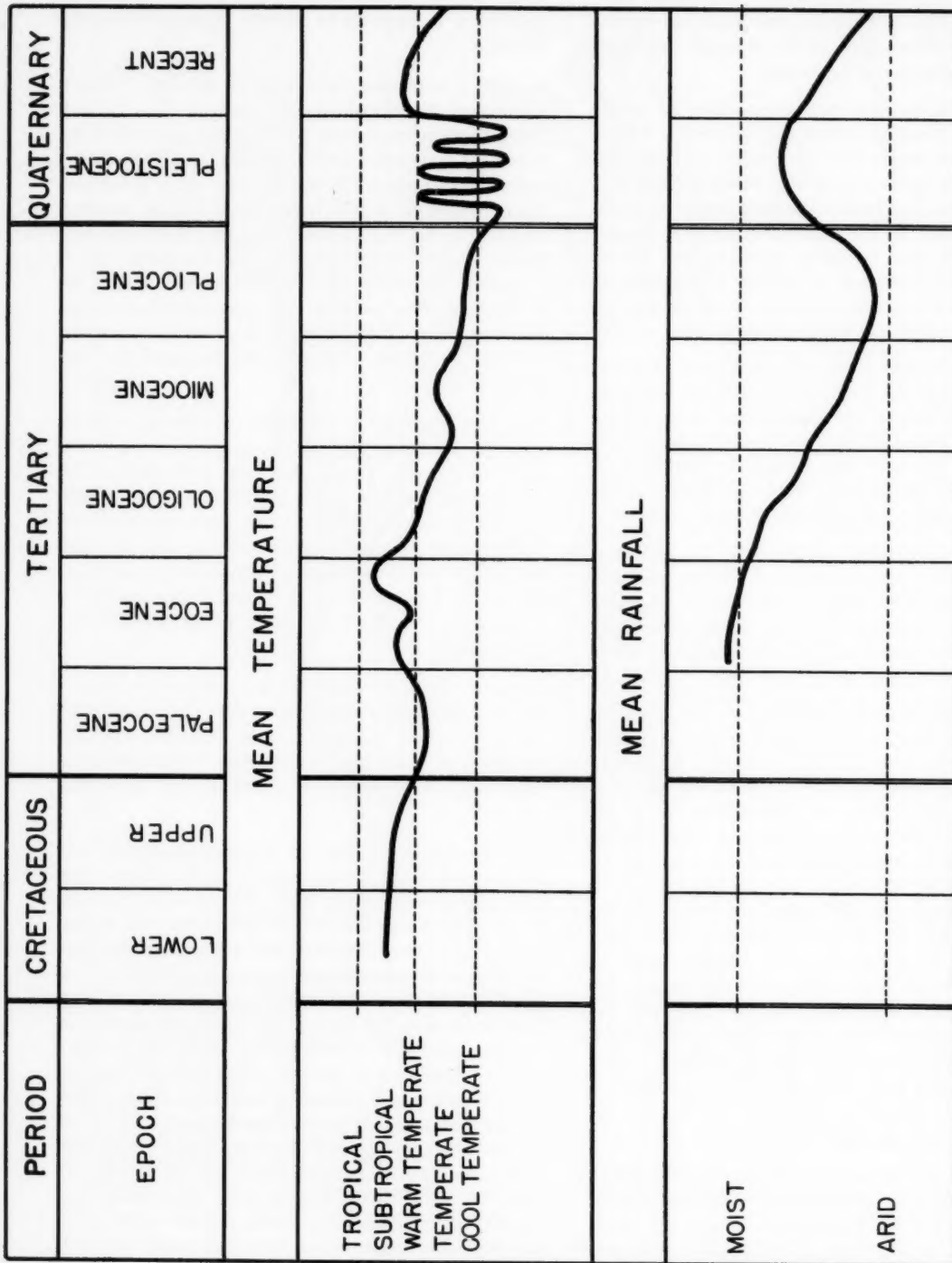
north-temperate-zone floras. These floras migrated southward in response to climatic changes during the Tertiary.

In 1886, J. S. Gardner, as quoted by Chaney (1936b), recognized the distribution of Tertiary floras as evidence of floral migration, and thereby established the basis for paleobotanical correlation and age-dating within that period. During Eocene time, temperate floras flourished in the Arctic. They had no counterpart in the typical Eocene floras of the middle latitudes. During Miocene time, the temperate floras migrated southward into the middle latitudes in response to cooling temperatures. According to Gardner, the recognition of these major floral types in a given section of Tertiary deposits can be used for age determination.

The Tertiary rocks of California provide an excellent area for studying the relationships between fossil spores and pollen, paleoecology and stratigraphy. The macroscopic paleobotanical record has been investigated more intensively in western North America than in any other part of the world. The ecological implications of fossil floras ranging in age from Upper Cretaceous to Pliocene have been interpreted by W. R. Chaney, D. I. Axelrod, and other authors listed in the bibliography.

In early Tertiary time, climates tended to become warmer throughout the world. This was responsible for major plant migrations away from the equator; tropical and subtropical forests invaded localities occupied by warm-temperate floras during the Cretaceous.

The Eocene was a time of warm climates and low topographic relief in the western United States. The seas transgressed widely upon the shores of the continent, and the absence of the present coastal ranges and the incipient development of the Cascades permitted the oceanic climate to penetrate almost to the Rockies. Only the latter mountain ranges, which had been uplifted at the close of the Cretaceous, served as a topographic and climatic barrier on the east. A more general circulation of air and ocean currents brought a warm and humid climate to western America. Other factors that may also have affected the climate are increased solar energy and possibly a land bridge between Alaska and Siberia, which cut off the Pacific basin from the Arctic. Eocene fossil floras show that the climate of Oregon and California was subtropical, and warm-temperate floras extended across the sites of the Cascade, Sierra Nevada, and Peninsular ranges into regions now desert.



TEXT-FIGURE 2  
CLIMATIC TRENDS, CRETACEOUS TO PRESENT

## TERTIARY SPORES AND POLLEN

Throughout most of the Tertiary period, however, North America was a rising continent. The sequence from marine to terrestrial deposits in the Eocene and Oligocene series of Oregon indicates a gradual withdrawal of the seas from the continental margins. The upbuilding of mountain ranges within the area reached its climax in the Pliocene and brought about changes in climate that resulted in marked alterations in the vegetation. Most of the subtropical elements of the Eocene forests were gradually eliminated from temperate latitudes by Middle Cenozoic time because lower winter temperatures and lessened precipitation were imposed by continental climates on an emerging land mass. Although less well known than the Eocene and Miocene floras, the vegetation of the Pliocene shows even more strikingly the effects of continued uplift. Much of the western United States was invaded by southern woodland vegetation during the latter part of the Tertiary. In Pliocene time, the southward-migrating northern forests met the northward-migrating woodland and desert vegetation. Meanwhile, the shift from summer to winter rainfall caused many of the northern genera to become extinct.

The general trends in the mean annual temperatures in the western United States from the Cretaceous to the present, and in rainfall from the Eocene to the present, are shown in text-figure 2. The time-scale is diagrammatic and bears no relationship to the duration of the periods or epochs. The temperature curve from the Upper Cretaceous through the Pliocene is based on Dorf's (1955) "Thermometers of the ages." Mean temperatures and rainfall during the Quaternary are the author's estimates.

The sequence of floral development through the Tertiary and into Recent time also shows an apparent increase in the diversity of the vegetation within limited areas. This diversity does not appear to have been caused by a greater number of species in the individual plant communities, but by an increase in the number and types of communities. Such a differentiation in the vegetation may be interpreted as the expression of a greater variety of habitats caused by varied topography, which in turn resulted from later Tertiary earth-movements (Chaney, 1936b).

The fossil spore and pollen record from the Tertiary sediments of California closely parallels the macroscopic fossil record. The difficulties of relating spores and pollen to living plants or to macrofossils impose some limitations on the use of the microfossils for ecologic interpretation. These limitations are offset in part, however, by the almost continuous record of

fossil spores and pollen, whereas macrofossils are found in a few dozen scattered floras at best.

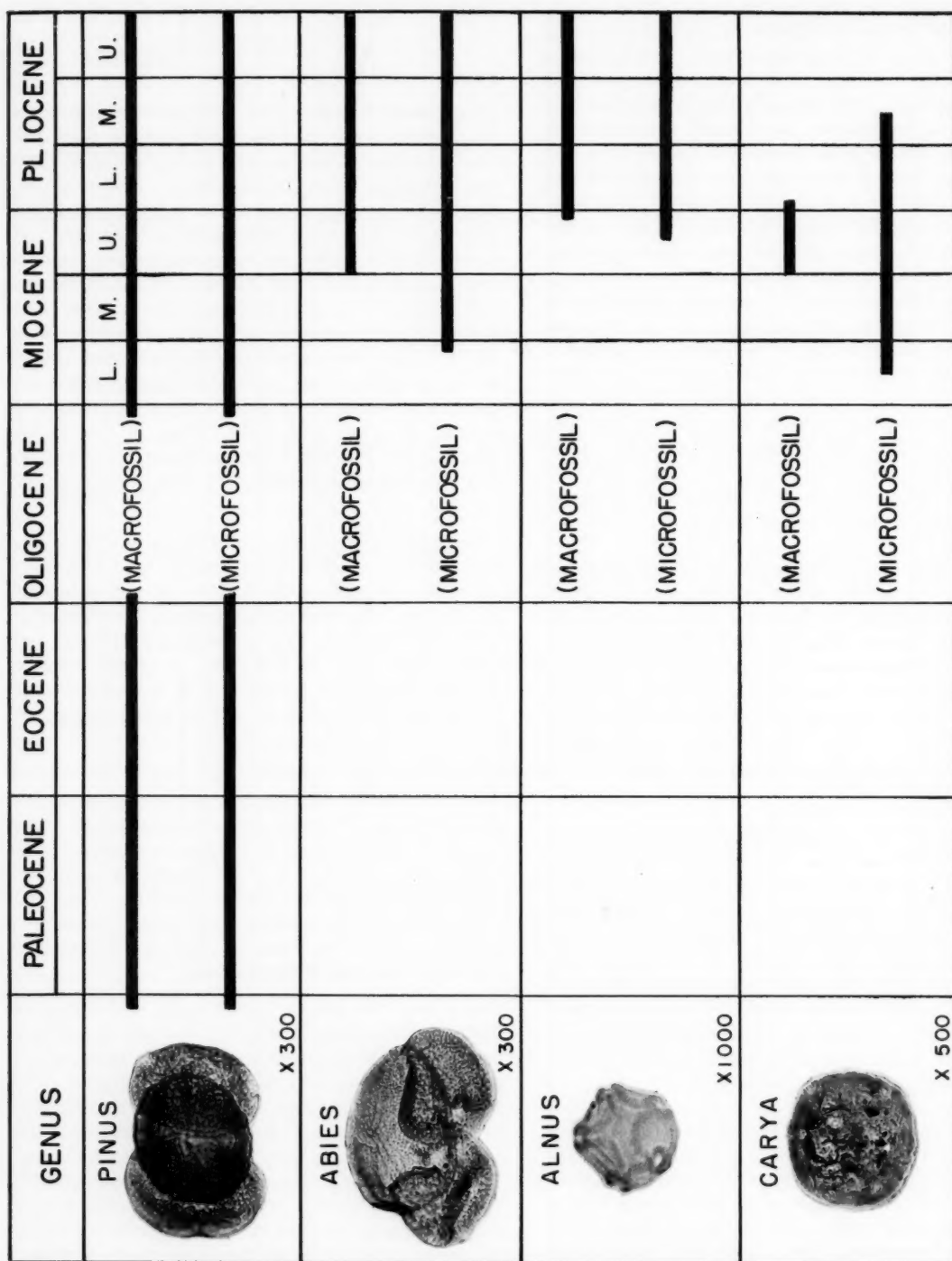
### TERTIARY POLLEN AND SPORE STUDIES

Comprehensive studies were made of the fossil spores and pollen found in subsurface samples from the vicinity of Bakersfield in the Central Valley of California. The samples were taken from a section of continuous Tertiary deposition in the valley center. Fossil spores and pollen were most abundant in number and in types in the younger sediments, and became progressively less abundant in the Miocene, Oligocene, Eocene and Paleocene. The scarcity of microfossils in the older sediments may be attributed in part to poorer sampling and in part to poorer conditions of preservation. (Many of the specimens found in the Eocene and Paleocene were badly corroded.) In general, however, the greater number of spore and pollen types in the Upper Miocene and Pliocene confirms Chaney's observation that the vegetation increased in diversity during the Tertiary.

The scarcity of fossil spores and pollen in the samples studied from the Paleocene, Eocene and Oligocene precludes zonation of the Lower Tertiary sediments at this time. However, sharp breaks in the number of pollen genera in the Lower and Upper Miocene and Middle Pliocene are indicative of major climatic changes. Because of the number of species involved, the Middle Pliocene break appears to indicate a particularly drastic climatic change, possibly the shift from summer to winter rainfall.

The difficulties encountered in comparing the stratigraphic ranges of fossil pollen with those of plant species based on macrofossils have been pointed out. Some easily identified genera, however, show a close correlation between the ranges based on pollen and those based on macrofossils. Pine (*Pinus*) pollen was found throughout the Tertiary, although the frequency increased markedly in the Pliocene.

Pollen from two genera (*Abies*, or fir, and *Carya*, or hickory) first appeared in the Lower Miocene. *Alnus*, or alder, pollen appeared first in Upper Miocene deposits. The *Abies* and *Alnus* pollen persisted until modern times, but *Carya* disappeared in the Pliocene break. Chaney shows all three genera appearing in the Upper Miocene, with *Carya* disappearing in the Lower Pliocene. Because the record is more continuous with spores and pollen than with macrofossils, the former may be expected to show an earlier appearance of the genera in an area. The stratigraphic ranges of *Pinus*, *Abies*, *Alnus* and *Carya* based on macrofossils accord-



TEXT-FIGURE 3

STRATIGRAPHIC RANGE OF MACRO- AND MICROFOSSILS IN THE TERTIARY OF CALIFORNIA



# TERTIARY SPORES AND POLLEN

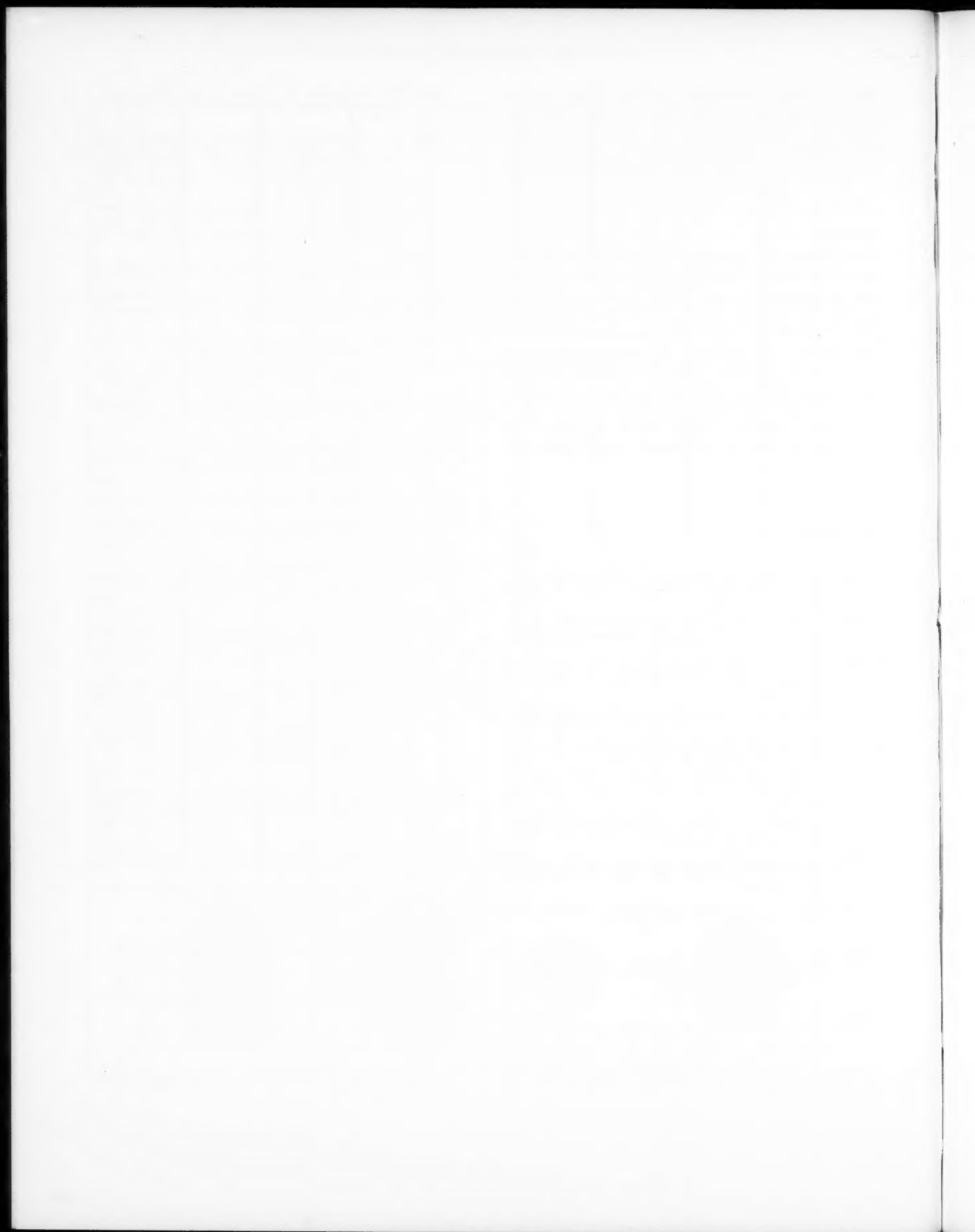
ing to Chaney, Condit and Axelrod (1944), and on pollen, are compared in text-figure 3. *Abies*, *Alnus* and *Carya* are representatives of the Arcto-Tertiary flora. The migration of these genera can be traced from the Eocene in Alaska to the Upper Miocene in California.

## SUMMARY

In conclusion, the paleobotanical and paleoecological history of western North America provides an excellent background for interpreting and evaluating the zonation of Tertiary sediments with fossil spores and pollen in California. Following Cretaceous time, there is relatively little evidence of evolutionary change among the seed-bearing plants. Correlation and geologic age-dating must therefore be based on changes in the fossil populations brought about by floral migrations. The extensive Tertiary floral migrations are shown equally well by macrofossils and by spores and pollen.

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**ABSTRACT:** Foraminiferal and larger invertebrate faunas inhabiting the northern and central coastal zone of the Argentine shelf are impoverished. Plankton is sparsely developed near the shore in these same areas. Spectrographic analysis of shells from the impoverished areas reveals lead, in addition to other trace elements. It is absent in the southern area, where the faunas are normal. The evidence seems to indicate that impoverishment may be due to traces of lead, probably brought into these areas by streams arising in the Andes.

## Applications of chemical ecology in the study of the foraminifera

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Study of the foraminiferal fauna of the western part of the Argentine shelf, especially of the part situated between the shoreline and a depth of approximately 100 meters, has shown that this fauna, in many localities, is impoverished. According to our data so far, this phenomenon is shown most clearly in the region between San Blas Bay and Bahía Blanca. However, it is also rather apparent in several other places. It can be stated, in summary, that the wide coastal zone of the northern and central parts of the shelf is more or less depauperated. The southern boundary of this zone is situated roughly between the Straits of Magellan and San Julián; its northern limit may not end with the geographic termination of the Argentine shelf, which, as is well known, lies opposite the Río de la Plata. It is also very probable that there are, in this vast area, relatively small isolated regions that are characterized by normal or even well-developed faunas. Later investigations should establish more exactly the boundaries of the whole zone, as well as the location of these "oases."

The southern part of the shelf, in the region of the Malvin Islands (Falkland Islands) and Tierra del Fuego, does not show such impoverishment. On the contrary, its foraminifera are numerous and well developed.

The somewhat depauperate character of the foraminiferal fauna is seen in the following features:

*Scantiness:* Qualitatively it is not very obvious. However, a thorough study of all the specimens encountered in the abundant material collected in the Gulf of San Jorge, San Blas Bay and the estuary of the Río de la Plata, including those whose state of preservation permitted only generic determination, revealed 148 species, 104 subspecies, and 144 indeterminate species. To be sure, these numbers may not be considered very limited, but in comparison with the number of species from other areas, neither are they very large. Let us take for comparison two examples, one from the north and the other from the south: Bermudez (1935) listed 249 forms from the central part of the north shore of Cuba. Heron-Allen and Earland (1932) found 419 species in the area of the Malvin (Falkland) Islands, and "some 200 species" at a single station situated just south of these islands.

Quantitatively the scantiness is very apparent. The scarcity of specimens in the samples collected is noteworthy. Even in rich material, many species are represented by only one isolated specimen. The "foraminiferal number," which represents the number of tests encountered in 1 gram of dry sediment, can be used in studying the fauna quantitatively. Of course, for greater accuracy, the rate of general sedimentation (terrigenous particles, etc.) should also be taken into account. Nevertheless, even without it, the foraminiferal number can give some impression of the comparative richness or sparseness of the

fauna studied. This number was found to be 29.2 for San Blas Bay, where the rate of sedimentation is very slow. For other nearby localities, it was approximately the same. In the region near the estuary of the Rio de la Plata it was 41, in spite of a higher rate of sedimentation, but near Tierra del Fuego, the foraminiferal number may be as high as 1400.

**Small size:** This feature is clearly evident when the average and maximum dimensions of the species are compared with those of the same species from the southern part of the shelf or from other seas. For example, in San Blas Bay, such cosmopolitan species as *Quinqueloculina seminulum* (Linné), *Triloculina subrotunda* (Montagu), *Robulus rotulatus* (Lamarck) and *Buccella frigida* (Cushman) reach maximum sizes of 0.7, 0.5, 0.4, and 0.43 mm., respectively. As is clearly revealed in the literature, these species are considerably larger in other seas.

**Loss of ornamentation:** Partial or sometimes complete loss of ornamentation can be seen in such species as *Quinqueloculina bicornis* (Walker and Jacob), *Bolivina striatula* Cushman, *Globulina caribbaea* d'Orbigny, *Bulimina marginata* d'Orbigny, and others.

**Tendency toward asymmetry:** This phenomenon can be observed, for example, in some representatives of the families Lagenidae and Nonionidae.

**Retardation:** Retarded specimens were observed in some places. For example, specimens of *Quinqueloculina intricata* Terquem were seen with only two chambers, representing the juvenile stage, although the specimens often were the normal size for adult individuals. The majority of these observations have been described in detail by the author in papers on the foraminifera of the Argentine shelf (Boltovskoy, 1954a, 1954b, 1954c, 1955).

Because the entire organic world is interrelated, it is logical to expect that other animal and plant groups should also be somewhat depauperated in this zone. A visit to a few coastal localities fully confirms this prediction. The sparseness of the population of these areas is striking, even in comparison with such regions as the shores of the Baltic or the Black Sea.

The author naturally expected that the impoverishment observed by him had already been extensively described and explained in the biological literature. That this is not the case is probably due to several reasons: First of all, the coastal and shallow-water fauna of the Argentine shelf has not been extensively studied. Sven Ekman, in "Zoogeography of the Sea" (1953), states that "the region between Patagonia

and Rio de Janeiro is one of the world's least known regions as far as the coastal fauna is concerned" (p. 214). In addition, investigators evidently have not paid much attention to this characteristic of the organic world on the Patagonian shelf. In any case, the author found in the literature only a very small number of papers on this subject, and in the majority of them, more was said about the relative richness of other faunas than of the absolute poverty of those on the Argentine shelf. Nevertheless, all that has been said is in full accord with the author's observations.

D'Orbigny (1839) was the first to state that the stations in the vicinity of the Malvin Islands were visibly richer in foraminifera than those near the Patagonian shore. Heron-Allen and Earland (1932) also mentioned this condition. They explained the richness of the Malvin Islands fauna as due to the influence of the current that comes from Drake's Passage, washes the Malvin Islands, and "... no doubt brings with it large food supplies in the shape of diatoms and other microplankton" (p. 295).

Gunter (1936) noted the great richness of the fauna near the Chilean coast in comparison with that near the Argentine shore. He explained the difference by saying that near the western border of South America there is a more intensive process of mixing of the waters, and these "... areas of mixture are frequently of special fertility for the production of plankton" (p. 234).

The latest reference found by the author in the literature is that of Hentschel (1936), who studied the material gathered by the "Meteor" Expedition. Hentschel writes that, contrary to the general rule that plankton increases in richness nearer the shore, which he saw clearly illustrated in the material collected by the "Meteor" near the African shores, the conditions near the Patagonian coast were reversed. "Doch erleidet diese Regel der Anreicherung auch Ausnahme, wie der z.B. die patagonische Küste" (p. 163). He found that the Patagonian shelf is poor in plankton and, moreover, that the plankton decreases in richness toward the coast. He also gives quantitative data for several areas on the shelf, from which it is possible to see that the poorest station is situated approximately opposite Bahia Blanca—Quequén, and the richest opposite the Straits of Magellan (p. 151). He offers no definite explanation for these phenomena.

These are all the data found by the author in the literature reviewed. However, confirmation of the author's data was also obtained from the following personal communications:



## CHEMICAL ECOLOGY OF FORAMINIFERA

Frenguelli, who has published numerous papers on systematic descriptions of Argentine diatoms, states: "The quantity of diatoms, neritic as well as planktonic, is much lower in the oceanic region that corresponds to the zone from the Straits of Magellan north to the parallel of Bahia Blanca than it is in other areas, for example, south of this zone." The author received similar data on the poverty of the molluscan fauna of this area in comparison with that of Tierra del Fuego from A. Carcelles, who is the author of several papers dealing with Argentine Mollusca.

The belief that the richness of the Malvin Islands fauna is due to the influence of Antarctic waters, which are, as is well known, very rich in plankton, seems to be quite logical and correct. However, no one has explained why the zone near the Patagonian shores is depauperated. In summary, the following statements can be made:

- 1) All faunas of the coastal zone of the northern (and greater) part of the Argentine shelf are somewhat depauperated.
- 2) A satisfactory explanation of this phenomenon has not yet been given.

In attempting to explain it, it would be possible to take into consideration the fact that a large part of the coastal zone of the shelf represents a region where the annual variation in water temperature is abnormally great. This results primarily from the character and direction of the marine currents in the area. In addition, some meteorological phenomena can also produce great changes in temperature. Capurro (1955, p. 93) states that the annual variation in temperature of the sea water in the coastal zone amounts to 10° C. or even more. It is obvious that these sharp changes in water temperature are unfavorable to marine life. Nevertheless, this explanation can not be taken as completely satisfactory, because the changes are not great enough to cause such impoverishment, and, furthermore, many other facts remain to be explained, for example, the abnormalities in the foraminiferal tests, why the poorest faunas are restricted to the regions of San Blas Bay and Bahia Blanca, why the quantity of plankton decreases shoreward, and why the foraminiferal fauna is poor in number although not in species.

In an article dealing specifically with the problem of the influence of food on the tests of foraminifera (Boltovskoy, 1954a), the author attributed the abnormalities of the tests to unfavorable food conditions. This conclusion was arrived at from a consideration of

the possible influence of all known factors. At the same time, the author added that he would not attempt to explain the origin of these unfavorable food conditions.

In discussing the environment and its influence, such factors as temperature, salinity, food and light are always taken into account, but the influence of chemical elements, and especially of the so-called minor or trace elements present in the medium, is usually not considered. Nevertheless, these trace elements certainly must affect organisms, especially in marine environments. By "trace elements" we mean chemical elements that are widely distributed in organisms, in water and in soil, but are present only in very minute quantities, usually in thousandths of one per cent or less. Such elements as cobalt, iodine, manganese, boron, bromine, zinc, copper, and lead are examples. Nearly fifty trace elements are known at present. Under natural conditions, they are ordinarily found (with rare exceptions) in the form of various chemical compounds in many hormones, vitamins, and ferments. Observations and experiments during the past twenty years have shown that their role in the lives of animals and plants is extraordinarily great. The health and general well-being of all living things depend largely upon their presence or absence. The study of this dependence has created a new branch of science, chemical ecology. We can say that chemical ecology is the study of the changes in organisms produced by trace elements.

The vast majority of observations and experimental work done so far relate to cultivated plants and domestic animals. The results have been striking. For example, it was found that the lack of infinitesimally small amounts of cobalt or copper in the soil induces disease in cattle, and that zinc is very important to many plants. In the light of these data, various phenomena of dwarfing and other abnormalities, which were previously inexplicable, now become understandable.

Considerably fewer observations and experiments have been made on invertebrates. However, what is known also confirms the great importance of trace elements. A very good summary of these researches is given by Tasch (1953). As this summary deals with dwarfed fossils, the harmful effects of the elements are emphasized. Tasch states: "Toxic effects of certain metallic cations (Cu, Pb, Sn, Hg, Ag) leading to the death of organisms were called 'oligodynamic' by Nägeli," and, further, "other investigators have also found that particular cations retard or stop growth" (p. 428).

To date, no work has been done on the chemical ecology of the foraminifera. However, by analogy with other groups of animals and plants we can infer that trace elements are also important to them, probably even more so than to more complicated organisms. Vinogradov, one of the greatest authorities in the study of trace elements and their role, came to the conclusion that "the lower plants have exceptionally great variability in their dependence on the quantity of trace elements in the medium" (1952, p. 16). He further states that in plants a complicated suite of superficial variations is observed, which have often been considered as different varieties, subspecies, mutations, and even new species. The variations that have such an origin are not hereditary, and if the plants are returned to their former environment, they revert to their former appearance. "But," he adds, "a species that for a long period has inhabited an environment with an abnormal amount of one or another chemical element fixes the variations thus originated" (p. 16).

In view of all these discoveries in the field of chemical ecology, the question naturally arises as to whether or not it might be worthwhile to seek an explanation

the chemical content of the tests. Each of these methods has its advantages. It is certainly also necessary to take into account all other possible factors in the medium.

Few papers are known that give data on chemical analyses of foraminiferal tests. An excellent summary of these publications is given by Vinogradov (1953). There are also a few publications that give data on spectrographic analyses of the tests of foraminifera (R. R. Revelle, A. Wood, R. Said, K. H. Wedepohl, C. Emiliani). However, all of the researches reported in these publications had other aims, and their results did not relate to the problems of chemical ecology.

As samples of the waters were not at the disposal of the author, tests were used in the spectrographic analyses reported below. The numerical poverty of the fauna restricted the author to specimens of only two species, *Quinqueloculina seminulum* (Linné) and *Buccella frigida* (Cushman). Both species occur south of Tierra del Fuego and also in San Blas Bay. The analyses were made by H. Freimuth, to whom the author is greatly indebted. The results of the analyses are as follows:

	SOUTH OF TIERRA DEL FUEGO	SAN BLAS BAY
<i>Quinqueloculina seminulum</i>	Ca, Fe, Mg, Si, Ti, Mn, Sn, Sr	The same elements and also Pb
<i>Buccella frigida</i>	Ca, Mg, Sr, Si, Al, Ti, Fe	The same elements and also Mn, Sn, Cu, Bi, Ag and Pb

of the unfavorable living conditions on the Patagonian shelf in the harmful influence of trace elements. The solution of the problem of the effects of trace elements upon foraminifera, as well as upon other organisms in general, probably lies in special laboratory experiments. Under such conditions, one can better measure the possible influences of other factors. But in attempting to solve the question of the effect of trace elements on the foraminifera of the Patagonian shelf, it was possible to pursue two paths: The first of these involved the determination of the trace elements present in oceanic waters taken from areas characterized by faunas of different development. The second involved the determination of the trace elements present in tests belonging to the same species but collected from different localities. It is to be supposed that the content of the water should be reflected in

Specimens of both species taken from San Blas Bay, where the fauna is the most depauperated, show the presence of lead. It seems probable that it is the lead that has caused the impoverishment at that locality.

The following postulate of the mechanism of foraminiferal impoverishment seems to the author to be the most likely: First of all, the lead salts present in the ocean waters of the locality influence plant life, decreasing productivity. Among the plant forms present are diatoms, which represent the principal food of foraminifera. Diminution in the quantity of diatoms produces unfavorable food conditions for foraminifera, leading to impoverishment, as the author has previously stated (1954a). This is an indirect influence, but at the same time there must also be a directly harmful effect of these salts on foraminifera.

# CHEMICAL ECOLOGY OF FORAMINIFERA

There are two ways in which these trace elements can get into the water. The first of these is in fluvial waters from the continent, and the second is in volcanic or meteoric dust from the atmosphere. The trace elements of nonmetallic character (I, F, Br, As, Bo, etc.) come chiefly from the second source.

In San Blas Bay and neighboring regions, the lead salts may be brought in by the Rio Negro and Rio Colorado rivers, which have their sources in the Andes, where there are rich lead deposits. On other parts of the shelf, they may also come from the Andes, as well as from other deposits situated relatively near the shores of the ocean. Such deposits are known in Patagonia. The possibility of the existence of lead deposits on the sea floor is also not excluded. The hypothesis of the continental origin of these trace elements accords well with Hentschel's observation, mentioned above, that the quantity of plankton decreases shoreward on the Patagonian shelf.

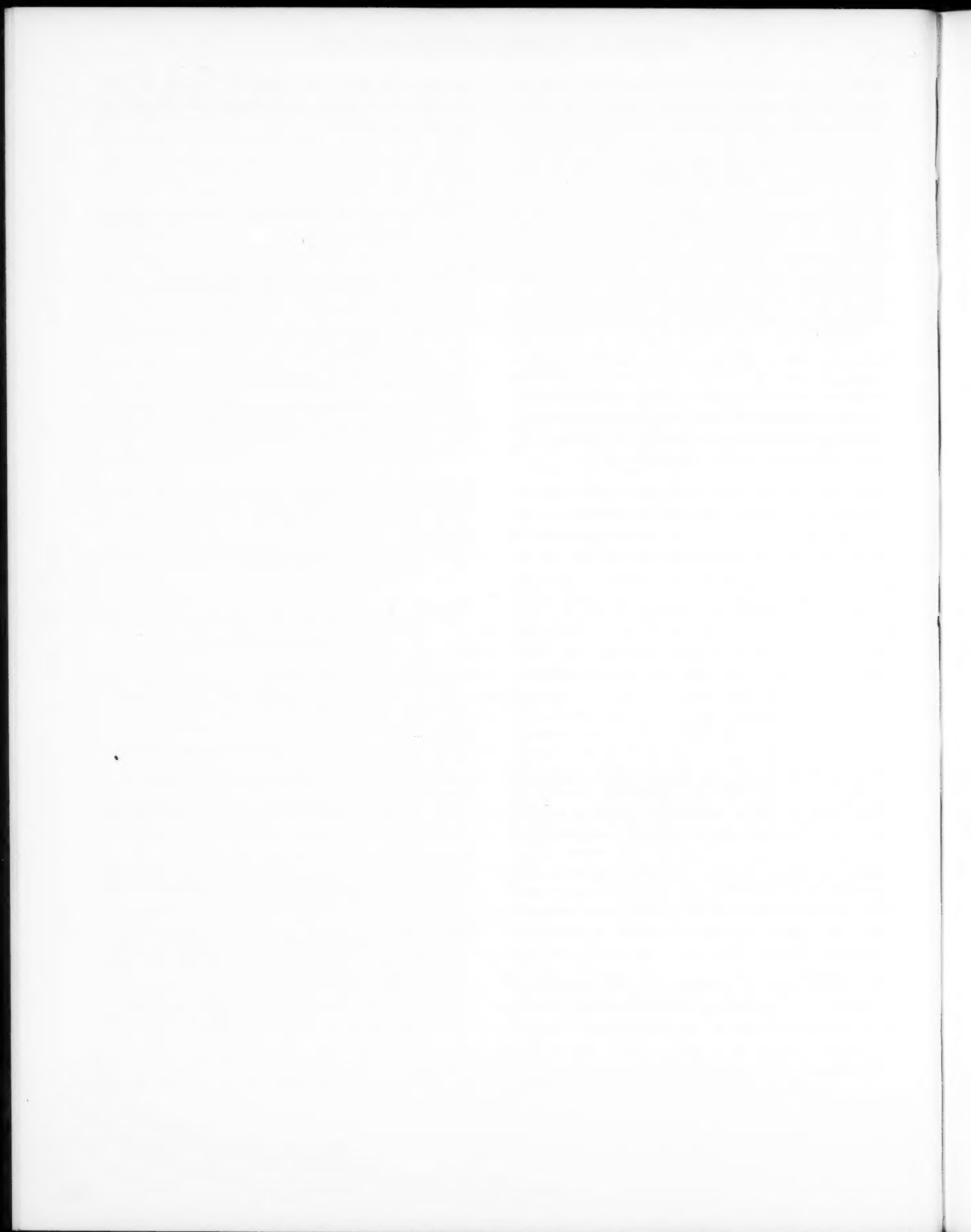
These data are far from conclusive, and further investigations should be made of the problem of impoverishment of faunas on the Patagonian shelf. It should also be remembered that the problem of the influence of trace elements on organisms is exceptionally complex. The quotation from Tasch, cited above, on the detrimental influence of copper, lead, tin, magnesium, and silver, is an oversimplification, and is not true of all of these elements. The same trace element may have different influences depending upon the quantity present and upon the organism involved. For example, copper in certain amounts is beneficial. Moreover, Kovalsky (1954) lists it among the trace elements (Cu, Co, Zn, I, F, Si, Br) that he says are "necessary for the life of animal organisms" (p. 12). He gives examples of specific diseases in cattle living in regions where this element is lacking (p. 19). But at the same time he also indicates that a surplus of copper is harmful and causes other defects (p. 19). A certain quantity of copper is also beneficial to invertebrates. An example is the garden snail (*Helix pomatia*), which reaches a very large size when the proper amount of copper is taken in (Kovalsky, 1954, p. 16).

The present paper is intended as a first step in the application of the ideas of chemical ecology to the study of foraminifera, and as a first step it is under-

standably far from the ideal. At present we are groping, but the author has no doubt that this method has great possibilities.

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ABSTRACT: New records of calcareous algae are given for the Permian, Jurassic, Cretaceous, Paleocene, and Eocene of the Middle East. New genera described are *Lithocodium* (Codiaceae) and *Pagodaporella* (Dasycladaceae); new species of *Epimastopora* and *Terquemella* are also described.

## Further records of fossil calcareous algae from the Middle East

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### INTRODUCTION

Since the publication in this journal of earlier accounts of the algal microflora of the Middle East (Elliott, 1955a,b), a number of new records have been made in the course of routine examination and comparison of thin sections; these are now listed as supplementary to the earlier work. My thanks are expressed to the Management and to the Chief Geologist of Iraq Petroleum Company, Ltd., for permission to publish this account.

### PERMIAN

In the Upper Permian limestone of Harur, in the northern part of Mosul Liwa, Iraq, certain algal debris appears to be that of a species of *Epimastopora* (see Pia, 1937), a dasyclad genus known from the Upper Carboniferous to Lower Permian of the United States, the Lower Permian of Europe, the Lower Permian of Siam, and the Upper Carboniferous to Upper Permian of Japan. The skeletal coating in this genus seems to have been very fragile and usually occurs fossil as fragments; it is not well understood. Wood (1943) considered it to be closely related to and possibly identical with the European and Canadian Carboniferous *Koninckopora*, but decided that *Epimastopora* was best left as a genus pending further knowledge of the species referred to it. The Iraq material resembles that figured for various Asiatic species (Endo, 1953, 1954; Konishi, 1953, 1954), but is distinct from them and is described here as new.

Family DASYCLADACEAE

Subfamily CYCLOCORINEAE

Tribe MASTOPORINAE

Genus *Epimastopora* Pia, 1923

*Epimastopora* was named by Pia (1923, pp. 65-66), reference being made to European Permian material figured as *Gyroporella*? sp. by Gortani (1906, p. 7, pl. 1, figs. 1-2), but no type species was named. Pia later (1937, p. 828, pl. 13, fig. 4) figured and commented on material of the same type as Gortani's figure 2, referring to it as *Epimastopora* sp. Several species of *Epimastopora* have since been described from the Upper Palaeozoic of America and Asia. I now name the material shown in Gortani's figure 1 *Epimastopora alpha*, and that in figure 2 *Epimastopora beta*, and select *Epimastopora beta* as the type species of the genus, in conformity with Pia's intentions. Unfortunately our knowledge of the genus is still too incomplete for a full redescription; it is for this reason also that Gortani's figures are here named separately, in spite of the fact that they have been interpreted (Wood, 1943, p. 209) as showing sections at different angles, because abundant fragments of the Iraq species described below are all of *alpha* type.

*Epimastopora minima* Elliott, new species

Plate 1, figures 1, 3

*Description:* Thallus fragmentary, presumed cylindrical, club- or keg-shaped, diameter up to 0.5 mm. or more, length unknown; wall thickness up to 0.182 mm.; pores

radiating upward and outward, increasing and decreasing in diameter to give a beaded or "fucoid" section, sometimes branching, varying much in size and arrangement, giving a "polka-dot" pattern in tangential section just short of the surface, these apertures being much smaller and more uniformly spaced (0.026 mm. approximate diameter; seven more or less in line along a distance of 0.25 mm.) than the swollen internal cavities (up to 0.065 mm. in diameter).

**Syntypes:** Numerous random sections figured in plate 1, figures 1 and 3, from the Upper Permian limestone of Harur (Mosul Liwa), northern Iraq; reg. no. W1.11374, Geol. Coll. Iraq Petroleum Co., Ltd., London.

**Remarks:** This species differs from others of the genus in its small size and combination of detail (see comparison table in Konishi, 1953, text-fig. 3), but does not, unfortunately, add to existing knowledge of the structure of the genus.

#### JURASSIC

The correspondence between the algae of the upper part of the Upper Jurassic in deep borings in the Dukhan oil field, Qatar, Persian Gulf, and those of the equivalent horizon in Switzerland was indicated by Elliott (1955b); it extends also to other micro-organisms, including the crustacean fecal pellet *Coprolithus salevensis* Paréjas (pl. 1, fig. 6). In a recent paper on the Swiss Purbeckian (Upper Jurassic), the encrusting coralline alga *Lithoporella* was recorded (de Loriol, 1954). This was surprising, for hitherto the coralline algae dated with certainty only from the Middle Cretaceous, whereas the presumably ancestral solenoporeids were thought to occur earlier. *Lithoporella* was believed to have appeared in the Tertiary, becoming more widespread geographically from the Eocene onward. The occurrence of an alga apparently indistinguishable from true Tertiary *Lithoporella* is now reported from the Upper Jurassic of Qatar; it is pre-

sumably the same as the Swiss Jurassic species. The writer can see no reason for separating this form (pl. 2, figs. 8-9) from the long-ranging Tertiary species *Lithoporella melobesioides* Foslie. The dasyclad genus *Clypeina* occurs commonly in the Upper Jurassic, is not recorded from most of the Cretaceous (except at bottom and top), and reappears commonly in the Lower Tertiary. Possibly *Lithoporella*, one of the simplest of its kind in structure, has a similar range. Johnson (1955) has recently indicated that the coral-line algae as a whole may have an Upper Palaeozoic origin; the present writer has seen only an abstract of this very interesting communication.

#### CRETACEOUS

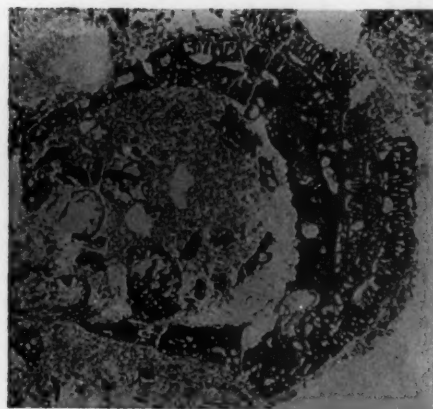
The subsurface Lower Cretaceous of the Rumaila oil field, Basra, has yielded a codiacid which is apparently new (pl. 1, figs. 2, 4-5). It shows the distinctive subdermal pattern of thick, irregularly branching threads characteristic of such members of the family as the familiar *Halimeda*, *Boueina* (Toula, 1884; Steinmann, 1899), and *Udotea* (Fritsch, 1948), but unlike the former two genera, which are segmented, and the latter, which grows into a thin stalked fan, the new genus is irregularly nodular in growth. Sections often show several irregular superimposed thalles, each with a thin confused inner layer and distinctive outer layer, and all facing outward; in transverse sections of the thin fan of the Recent *Udotea* (the related *Avrainvilleopsis* is known from the Paleocene), the subdermal layers are set back to back, with a thin layer of longitudinal threads between them. The new genus thus combines the nodular external form of alleged Codiaceae such as *Cayeuxia* (Jurassic) and certain Palaeozoic genera, with the internal structure of the segmented or erect Codiaceae already mentioned.

#### EXPLANATION OF PLATE 1

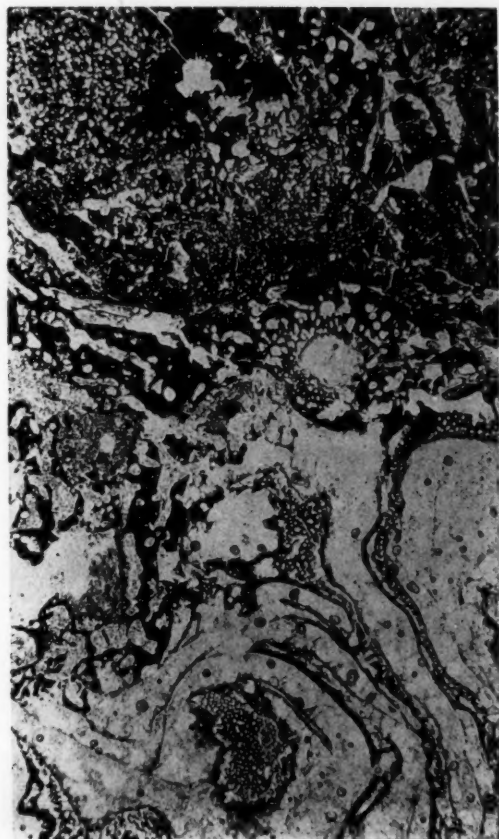
- 1, 3 *Epimastopora minima* Elliott, n. sp.  
Numerous random sections,  $\times 28$ . Upper Permian limestone; Harur, Mosul Liwa, northern Iraq. Reg. no. W1.11374.
- 2, 4-5 *Lithocodium aggregatum* Elliott, n. gen., n. sp.  
Various sections,  $\times 12$ . Lower Cretaceous; Rumaila no. 4 well, Basrah Liwa, southern Iraq. Reg. nos. Ru.192, 193, 191.
- 6 *Coprolithus salevensis* Paréjas  
Transverse and longitudinal sections,  $\times 55$ . Upper Jurassic; Dukhan no. 28 well, Qatar, Persian Gulf.



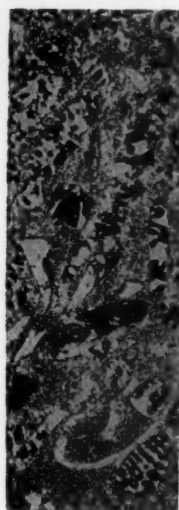
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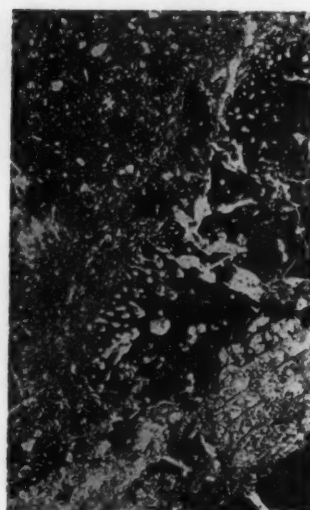
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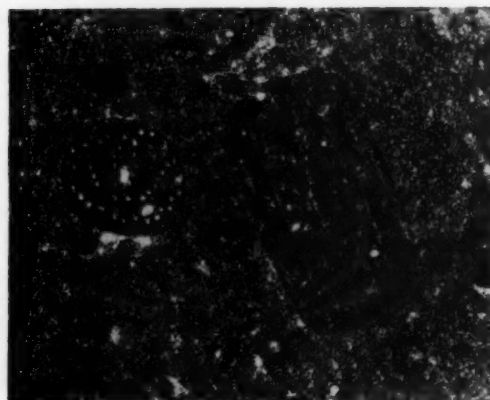
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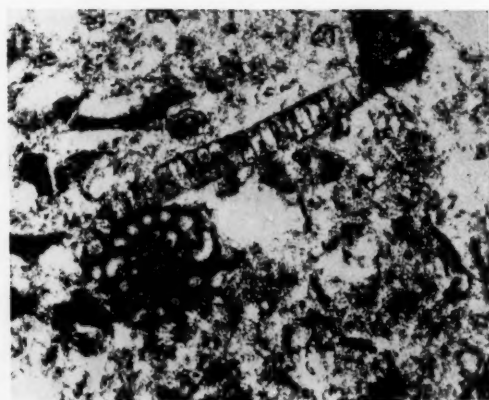
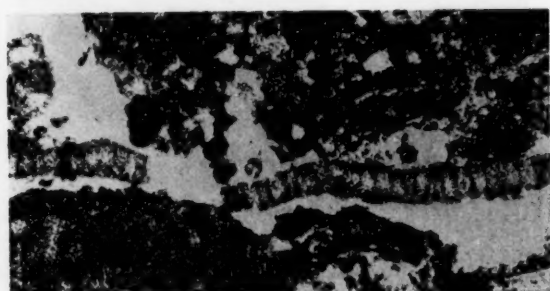
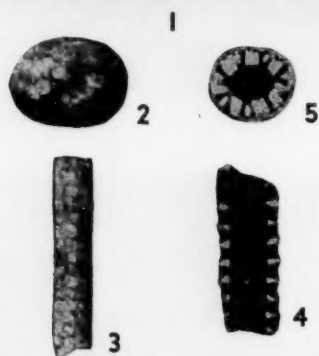
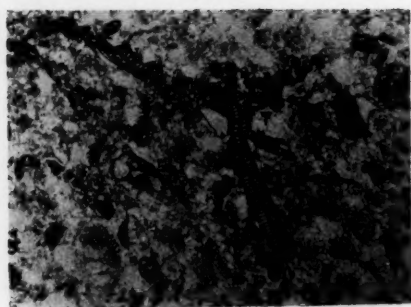
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6





## MIDDLE EAST CALCAREOUS ALGAE

### Family CODIACEAE

#### Genus *Lithocodium* Elliott, new genus

Encrusting or nodose Codiaceae with a subdermal structure similar to that of the segmented *Boueina*. Lower Cretaceous of Iraq. Type species: *Lithocodium aggregatum* Elliott, n. sp.

#### *Lithocodium aggregatum* Elliott, new species

Plate 1, figures 2, 4-5

**Description:** Irregular nodular growths largely formed of thin superimposed thalles; growths 2-3 cm. across, thalles very variable in thickness, commonly about 0.25 mm., each showing an inner layer of very irregularly disposed coarse filaments without definite orientation and an outer layer of irregularly radial filaments, each of which divides into finer filaments which sometimes appear to reunite. The mode of calcification in the living plant was apparently similar to that in the Recent *Halimeda*. Recrystallisation has affected more inner layers than outer ones. Where the interior of a nodule is not affected by recrystallisation it may show either many concentric thalles around a small original thallus, or a larger mass of irregular tubules, never radial and presumably of *Lithocodium* itself, surrounded by several thin thalles, or a non-algal centre within the outer thalles. This centre is filled with calcareous matrix (including fragments of *Lithocodium*), and suggests original growth of the outer thalles either around an object now absent, or around a pebble or nodule of calcareous matter on the sea floor.

**Holotype:** The specimen figured in plate 1, figure 5, from the subsurface Lower Cretaceous of Rumaila no. 4 well, Basra Liwa, Iraq. Reg. no. Ru.191.

**Paratypes:** The specimens figured in plate 1, figures 2 and 4, from the same locality and horizon. Reg. nos. Ru.192, 193.

**Other material:** Numerous random sections from the same locality and horizon.

**Remarks:** *Lithocodium* appears to bear the same relation to *Boueina* as, for example, *Lithothamnium* does to *Coralina*. It is of especial interest because the nodular alleged Codiaceae of the Palaeozoic and Mesozoic possess a different internal structure.

At a higher level in the Cretaceous, in the Maestrichtian of Kurdistan, northern Iraq, a species of the codiacid *Ovulites* has been noted. It differs from *Ovulites morelleti* Elliott, described in this journal (Elliott, 1955b) from the Paleocene of the same area, in being smaller, proportionally slimmer, thinner-walled, and more consistently rod-like, but it is not well preserved and the pores could not be measured; it is therefore not described here. Cuvillier (1954) has referred to a Cretaceous (Cenomanian) occurrence of this genus from Aquitaine, southern France, as *Penicellus* sp. From the same Iraqi horizon and area, although in a different facies, *Cymopolia tibetica* Morellet is to be recorded. This species, from the Maestrichtian of Tibet (Morellet, 1916), has been recorded from the Paleocene of Turkey by Pfender (1940), who ascribed the type horizon to the Paleocene also, on foraminiferal evidence. *Cymopolia tibetica* was, however, originally described in association with the Maestrichtian foraminifer *Omphalocyclus macropora* (Lamarck) and below beds containing the Upper Cretaceous brach-

### EXPLANATION OF PLATE 2

- 1 *Distichoplax biserialis* (Dietrich)  
Thin section,  $\times 25$ . Paleocene; near Sulemania, northeastern Iraq.
- 2 *Terquemella globularis* Elliott, n. sp.  
Holotype, solid specimen showing infilled sporiferous pores,  $\times 55$ . Paleocene; Bekhme, Erba Liwa, northern Iraq. Reg. no. W1.2559.
- 3-4 *Pagodaporella wetzeli* Elliott, n. gen., n. sp.  
3, holotype, solid specimen,  $\times 30$ . 4, vertical section,  $\times 30$ . Paleocene; Bekhme, Erbil Liwa, northern Iraq. Reg. nos. W1.2561, W1.2560.
- 5-6 *Furcoporella diplopore* Pia  
5, approximately transverse section to show horizontal pore-pairs,  $\times 30$ . 6, vertical-oblique section,  $\times 25$ ; note progressive divergence of pores above and below. Paleocene; near Sedelan, Sulemania, northeastern Iraq.
- 7-11 *Lithoporella melobesioides* Fosløe  
Various sections,  $\times 55$ . 7, 10-11, Middle to Upper Eocene limestone; Banik, Mosul Liwa, northern Iraq. 8-9, Upper Jurassic; Dukhan no. 28 well, Qatar, Persian Gulf.

iopod *Kingenia hebertiana* (d'Orbigny); it is the overlying "Danian" series which is now recognised as basal Tertiary. Either *Cymopolia tibetica* ranges from Maestrichtian to Paleocene, or the difference between the forms from the two horizons is not visible in thin section.

#### PALEOCENE

A number of interesting new records may be added to the rich algal microflora of the Kurdistan Paleocene (Elliott, 1955b). In that publication, two species of *Acicularia* were figured but not named or described by the writer; further material permits recognition of these as *Terquemella* spp. One of them (Elliott, 1955b, pl. 1, fig. 11 (right-hand figure only) and fig. 12) is *Terquemella bellovacina* Munier-Chalmas, described from the Paleocene of northern France; the other (Elliott, 1955b, pl. 1, fig. 11, left-hand figure only) is here described as new.

#### Family DASYCLADACEAE

##### Tribe BORNETELLAE

##### Genus TERQUEMELLA Munier-Chalmas, 1877

##### *Terquemella globularis* Elliott, new species

Plate 2, figure 2

**Description:** Near-spherical or flattened ovoid solid calcareous body, about 0.390 mm. in diameter; hollow globular pores (spore-cavities) 0.033-0.039 mm. in diameter just within outer edge over whole surface, so that equatorial sections show about eighteen of them in section, and tangential sections about 0.170 mm. in diameter show eight.

**Holotype:** The specimen figured in plate 2, figure 2, from the Paleocene of Bekhme, Erbil Liwa, northern Iraq; reg. no. W1.2559, Geol. Coll. Iraq Petroleum Co., Ltd., London.

**Other material:** Numerous thin sections from the Paleocene of northeastern Iraq (Elliott, 1955b, pl. 1, fig. 11, left-hand figure).

**Remarks:** *Terquemella* spp. from the Eocene of the Paris Basin were stated by Morellet and Morellet (1922) to be the loose dissociated sporangial bodies from various members of the Bornetellae; Mesozoic *Terquemella* spp. are of uncertain origin. *Terquemella globularis* is considered to fall in the former class.

Other algal remains are *Distichoplax biserialis* (Dietrich) (pl. 2, fig. 1) and *Furcoporella diplopore* Pia (pl. 2, figs. 5-6). *Distichoplax* was founded by Pia (1934) for a very peculiar thin melobesoid alga pre-

viously figured by Trauth (1918) from Austria and by Dietrich (1927) from Persia. Pia added records from the Carpathians (Czechoslovakia) and the Pyrenees, and the genus is also recorded from Assam (Rao, 1943). The range is thus given as Middle to Upper Eocene, but in every case there is some doubt because of the lack of exact faunal dating, possible reworking of material, or similar causes. Eames (1952) listed this alga as characteristic of the Paleocene of western India and western Pakistan, and drew attention to its alleged much greater time-range elsewhere. Dr. Eames also states (personal communication) that in his experience and in that of Dr. M. Glaessner, all records are almost certainly Paleocene in Persia, and that it is known commonly from Sicily to Papua, always from the Paleocene only. The Iraq occurrence is in the Paleocene/Lower Eocene of the Sulemanian district, northeastern Iraq; Dr. M. Chatton lists it (unpublished records) from the Paleocene and Lower Eocene of southern Oman, Arabia. It would seem, therefore, that it is characteristic of the Paleocene, and does not occur or is rare in the Middle or Upper Eocene.

*Furcoporella diplopore* was described by Pia (1918) from reworked material in Austria (age given as Middle Eocene, but possibly Paleocene or Lower Eocene). It has since been recorded by Pfender (1940) from the Middle Eocene of Egypt and Syria. Little can be added to our knowledge of this plant, as apparently calcification was confined to the forked bases of primary branches close to the main stem-cell. The Iraq specimens are from various beds of the Paleocene to Middle Eocene succession of Sedelan and elsewhere in the Sulemanian district, northeastern Iraq; also from Banik, Mosul Liwa, northern Iraq. These fossils attain a larger size than those examined by Pia and Pfender (length (incomplete) up to 3.5 or 4.0 mm.; diameter up to 0.57 mm.; d/D about 50%; median pore-diameter about 0.050 mm.), but they are recognisably the same species, showing whorls of six or seven pore-pairs, each pair bifurcating in a straight-sided V-formation, on the horizontal plane, from a single inner opening to two outer openings; in vertical section the pores are seen to be at right angles to the main axis, and to have noticeably expanded ends. About twelve or thirteen whorls occur per millimeter of length. Smaller examples, comparable to the type material, are common.

In addition to these two species, a new dasyclad, comparable to *Furcoporella* and *Griphoporella* in that the calcification preserved gives no clue to the sporangial structure in life, is here recorded.

# MIDDLE EAST CALCAREOUS ALGAE

## Family DASYCLADACEAE

### Genus *Pagodaporella* Elliott, new genus

Small tubular dasyclad skeleton showing external vertical rows of large alternating pores with small calcareous inter-pore portions, the pores widening sharply from within outward. No trace of sporangia preserved. Paleocene of Iraq; Kurdistan.

### *Pagodaporella wetzeli* Elliott, new species

Plate 2, figures 3-4

**Description:** Tubular hollow cylindrical dasyclad; fragments up to 1 mm. in length seen, diameter about 0.34 mm., d/D about 58-66%, octagonal in cross-section; pores externally roughly hexagonal, relatively large, close-set and in regular alternating rows, eight or nine per mm., widening rapidly from within outward (inner diameter 0.040-0.050 mm., outer diameter 0.065-0.090 mm.); in section the wall material appears as small spaced triangles or wedges of calcium carbonate, the apices outward.

**Holotype:** The specimen figured in plate 2, figure 3, from the Paleocene of Bekhme, Erbil Liwa, northern Iraq; reg. no. W1.2561.

**Paratype:** The specimen figured in plate 2, figure 4, from the same locality and horizon; reg. no. W1.2560.

**Other material:** Various thin sections from the Paleocene of Bekhme and Banik, Iraq.

**Remarks:** This species is dedicated to R. Wetzel, Research Stratigrapher with the Iraq Petroleum Company. Most of the algae described by the writer have come from his carefully collected stratigraphic samples.

## Eocene

*Lithoporella melobesioides* Fosløe (pl. 2, figs. 7, 10-11) is now recorded from the Middle Eocene limestone of Banik, Mosul Liwa, northern Iraq; it has also been found in the Lower Eocene of Sulemania, Iraq, and of southern Oman, Arabia. Although it is not uncommon in the Tertiary and has worldwide distribution in present-day warm waters, records from the Middle East are few. It has been noted previously in the Pliocene of Palestine (Lemoine, 1939, p. 110).

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**ABSTRACT:** Three new genera, *Begia*, *Coxites* and *Rabanitina*, comprising nine new species, are described from the Middle Cretaceous, mostly from deep boreholes near Basra, southern Iraq. *Begia* resembles *Gyroldina* but has an internal toothplate and is referred to the family *Ceratobuliminidae*. *Coxites* is similar to *Begia*, but the toothplate is complex. *Rabanitina* is similar to *Begia* when immature, but has a terminal involute stage that closely resembles *Barkerina* Frizzell and Schwartz, 1950, including a complex internal toothplate. *Coxites* and *Rabanitina* seem too isolated to be included in the family *Ceratobuliminidae*, and the new family *Barkerinidae* is proposed for them. The principles introduced by Hofker (1951a) are used as the key to our understanding of these new genera, although there are a number of objections to accepting the taxonomy as a whole. With certain reservations, the concept of the *Dentata* can be applied to these genera without modification.

## Three new Cretaceous genera of foraminifera related to the *Ceratobuliminidae*

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### INTRODUCTION

This work is published through the courtesy of the Chairman and Directors of the Iraq Petroleum Company and of the British Petroleum Company. Investigation of these faunas was begun by Mr. P. T. Cox, and contributions have since been made by Messrs. V. Boileau, A. N. Thomas, H. V. Dunnington and P. Rabanit, but this is the first publication on the subject. The author is grateful to Mr. P. T. Cox, Mr. F. E. Wellings, and Dr. F. R. S. Henson for the opportunity to complete the investigation. My thanks are due to Dr. F. E. Eames and Dr. E. Schijfsma for their valuable comments.

Occurrences of *Begia* and *Coxites* in various hard limestones of the Middle Cretaceous of the Middle East have been known for many years. It is only recently, however, that samples from deep boreholes in the Basra Petroleum Company's oil fields have yielded an abundance of separate specimens, thus providing the basis for an adequate description.

The geology of this region is discussed in a forthcoming paper by R. M. S. Owen and S. Nasr: "Stratigraphy of the Basra-Kuwait area." They divide the pertinent part of the Middle Cretaceous into the following formations (in ascending order):

- 1) Maaddud limestone, with *Rabanitina basraensis*, *Iraqia simplex* Henson, 1948, *Trocholina altispira* Henson, 1948, *Trocholina lenticularis* Henson, 1948, *Trocholina arabica* Henson, 1949, and *Orbitolina*

cf. *concava* Henson, 1948. Juvenile specimens of *Rabanitina* are liable to give rise to records of *Begia* in this formation, but *Begia* itself has been found in beds thought to be homotaxial but lacking the associated fauna.

- 2) Ahmadi shale, containing *Praealveolina cretacea* (d'Archiac).
- 3) Rumaila limestone, with *Orbitolina* cf. *concava* var. *qatarica* Henson, 1948.
- 4) Mishrif limestone, with *Begia gyra*, *Begia calcarata*, *Begia concava*, *Begia convexa*, *Begia conica*, *Begia glomerulata*, *Begia perforata*, *Coxites zubairensis*, *Multispirina iranensis* Reichel, 1947, *Cisalveolina fallax* Reichel, 1942, *Cisalveolina lehneri* Reichel, 1942, *Praealveolina cretacea*, *Dicyclina qatariensis* Henson, 1948, and *Pseudochrysalidina conica* (Henson).

The Maaddud, Ahmadi and Rumaila formations are placed in the Cenomanian by Owen and Nasr. A case can be made for an upper Albian age, on the grounds that *Iraqia simplex* was originally stated to be Lower Cretaceous in occurrence, and unpublished information suggests that *Orbitolina* cf. *concava* occurs in the Albian of northern Iraq, Iran and Qatar. In support of this idea, it is conceded that the Mishrif, dated by Owen and Nasr as Turonian, has a fauna of which the known records in the literature are Cenomanian. In



spite of this fact, Owen and Nasr's opinion is probably correct. The type locality of *Iraqia simplex* is in fact either Cenomanian or so high in the Lower Cretaceous that a Cenomanian occurrence would not be surprising. The Albian occurrences of *Orbitolina* cf. *concava* are not established beyond all doubt, and it is certainly unlikely that this species is excluded from the Cenomanian of the Middle East. The Mishrif fauna occurs in the Kuh-i-Bingistan area of Iran with *Orbitolina* cf. *concava*, and is dated by Henson (1948) and by Reichel (1942) as Cenomanian, but Reichel was prepared to consider a Turonian age. Unpublished records show that the upper beds in Iran with this fauna lack *Orbitolina* cf. *concava* but contain *Vola alpina*. This part is therefore probably Turonian. The Mishrif rests conformably on the Rumaila, which is therefore unlikely to be older than Cenomanian. The Cenomanian age of the Maaddud is based on less certain grounds, but is probable.

#### TAXONOMIC DISCUSSION

In previous work (Smout, 1954, 1955), the writer has emphasised the distinctive crystalline wall structure of the canaliculate foraminifera of the superfamily Rotaliidea. The group with which we are now concerned are non-caliculate and without evident secondary thickening, so that their morphology is best understood if a clear distinction from the Rotaliidea is made. In many classifications, genera such as *Gyroidina*, *Cibicides* and *Valvulineria* appear either in the family Rotaliidae or closely associated with it, but they do not show laminated thickening of the chamber wall, and appear to belong to a plexus of forms that is distinct from the Rotaliidea, and possibly also from the Discorbidea. This has delayed recognition of the possible relationships of *Ceratobulimina*, recently brought into prominence by Hofker (1951a).

Obvious differences of wall structure have always been taken as important taxonomic criteria at the superfamily level. Wood (1949) has given the subject added precision, and it will be convenient to summarise his conclusions:

**Agglutinated:** The basic material is granular calcite secreted in granules with random orientation and presumably about 5 to 10 $\mu$  in diameter. Their granule size is difficult to estimate because they form a cement in which variable amounts of foreign grains are set. Perforations are occasionally present.

**Granulate:** The test is composed of grains of calcite in random orientation. They are about 5 to 10 $\mu$  in diameter. Perforations are sometimes present. The only

difference from the agglutinated structure is the absence of incorporated matter. The general appearance is usually finely granular, and is sometimes difficult to distinguish from a specimen of the first group, in which the agglutinated grains are fine calcite. In some cases the test is highly polished; usually the chamber walls are opaque, but when very thin they may appear hyaline.

**Porcellanous:** The test is composed of very small grains of calcite, about 0.5 $\mu$  in diameter. They are usually randomly arranged but may sometimes have a preferred orientation, although far from complete parallelism of the optic axes. Perforations are uncommon but do occur in some species. The test appears polished and opaque, usually very white. In section, a fresh test appears brown and translucent. When slightly altered, the shell material appears grey and opaque in section and chalky in the solid. The grain size is increased. In this condition, distinction from the granulate group is not always possible. In rare cases, foreign grains may be agglutinated on the outer surface.

**Radial perforate:** The test is composed of fibres of calcite, all of which are elongated along the *c*-axes, which are arranged perpendicular to the chamber walls. Perforations are always present.

**Spicular:** The test is formed of secreted spicules.

**Coarsely crystalline:** The test is composed of one or a few crystals, the growth of which has been controlled by the organism to form a test of the appropriate shape. Perforations are often present. There is some doubt that this type is correctly described.

Wood makes a strong case for disregarding the presence or absence of perforations in major taxonomy. There is a strong tendency for certain groups to be imperforate, but it seems likely that most of them have perforations in certain species. In many cases it does not seem suitable to use this character even on a generic level.

The presence of agglutinated material in the test is also a less definite character than might be supposed. In some cases, e.g., the Lituolidae, it seems an essential character, and the whole of the shell material is involved. In the Valvulinidae and Verneuilinidae, many genera have definitely agglutinated tests and others have no trace of agglutinated matter (Wood, 1949, p. 234). Some have a few grains on the outer surface of the chamber wall. Within the Lituolidae, one must admit some families that have agglutinated tests only, others that have granulate tests only, and some in which these characters are variable.

The determination of the crystal structure of a test is not easy in fresh material, and fossil tests are often altered and permineralised in a manner that renders the original crystal structure a matter of interpretation rather than of rigorous determination. Bandy (1954) and Troelsen (1955) claim that aragonite is found in the tests of several genera, including *Ceratobulimina*. The type species, *Ceratobulimina contraria* (Reuss), is placed in the radially fibrous group by Wood (1949). The supposition has been that the radially fibrous tests are composed of calcite. Several possible explanations of Troelsen's findings come to mind, but obviously there is need for further research, and this must be done on fresh material to avoid the effects of solution, infiltration and alteration that can occur in fossil tests. Todd and Blackmon (1956) claim that the Ceratobuliminidae have a wholly aragonitic test, although most foraminifera have a wholly calcite test.

Usually the first and fourth groups retain their original structure, but if severely altered, the calcite of any group reforms as granular calcite that may be coarser than the granules of the second and third groups. The general appearance often permits determination of the shell material, although a certain number of errors will be made by simple inspection. The presence of perforations in granulate tests is often doubtful; they are frequently very fine, and a low degree of alteration causes the granules to grow and obliterate them.

Hofker (1951a) has proposed a classification based on recognition of homologies, particularly of the apertural characters and the associated toothplate which is found in numerous genera of foraminifera. The toothplate should be distinguished from an apertural tooth, which is an appearance caused by the shape of the aperture. According to Hofker, toothplates appear either as a plate inside the chamber, an imperforate area of the apertural margin, an external imperforate plate or carina, or a combination of such features. It is difficult to accept such a variety of structures as homologous, but for the moment only the internal toothplates concern us. Hofker's treatment of these in subsequent papers is a vital contribution to the present study.

The crystalline wall structure of the test is not considered by Hofker, and he includes examples of most types in his Ordo Dentata. Porcellaneous forms, represented by the Peneroplidae, may be rejected as unrelated to the rest of the Dentata. The porcellaneous foraminifera form a closely knit group that has no obvious relationship to the rest of the foraminifera, except for the class characters and the slender relationship indicated by the perforate nucleoconch. The strict bilateral symmetry of the Peneroplidae is not typical in the Den-

tata, and the simple forms have no toothplates. The internal partitions found in complex genera have no evident relationship to a toothplate. They, and the buttresses found in some genera, appear suddenly and are not evolved by elaboration of simpler structures.

The Valvulinidae are considered by Hofker to be the root stock of the Dentata, although this is the only arenaceous family included. The dissimilarity here is not so great, for many of the Valvulinidae have little or no arenaceous matter, and the granulate cement grades into a thick granulate wall. The trochoid habit and toothed aperture are suggestive of a relationship to the Dentata, and particularly to the Ceratobuliminidae. On the other hand, few of the Dentata are thick-walled, except for the genera with thickening and with radially fibrous wall structure. The Valvulinidae do not have internal toothplates such as are found in the typical Dentata. When complex internal structures are present in the Valvulinidae, they first appear, as in the Peneroplidae, as a number of discrete elements and not as a single toothplate that becomes complex as evolution progresses. The toothed aperture of *Begia* and the fairly thick walls of *Rabanitina* and *Barkerina* suggest some affinity with the Valvulinidae, but not enough to require formal taxonomic association.

The radially fibrous, laminated, thickened type of wall is common among families assigned to the Dentata by Hofker. In many instances it would be impractical to separate the granulate from the fibrous forms, although most of the more difficult cases occur among the thinner-walled representatives of both groups. *Begia* has a strong resemblance to *Reinholdella*, which has a well developed toothplate and a toothed aperture, but *Reinholdella* has a strongly thickened, radially fibrous wall, and there is a characteristic difference in the general shape of the test. *Reinholdella* shows very striking resemblances to the Amphisteginidae (Asterigerinidae), as noted by Brotzen (1948) and by Hofker (1951a, 1952), and as can be seen by comparing *Reinholdella pachyderma* and *Reinholdella brandi* Hofker, 1952, with *Amphistegina lopeztrigoi* and species of *Helicolepidina* described by Barker and Grimsdale (1936). The apertural similarity is remarkable. Nevertheless, some doubt remains because there is no continuity of record, and Hofker (1954) placed *Reinholdella* in the Epistomariidae.

Although the possibility cannot be discounted that canal systems may have been derived from toothplates in certain cases, it is probable that canal systems such as those of the Nummulitidae are not homologous structures. In any case, the canaliculate foraminifera

are distinctive enough to deserve separation from the *Dentata*, which constitute a much more consistent and understandable group without them. Fortunately, these questions do not affect the taxonomy of the genera with which we are at present concerned.

Hofker includes in the *Dentata* numerous genera that have thin, unthickened chamber walls and a trochoid habit. Some have granulate and some have radially fibrous but not obviously laminated shell material. Many have an obvious toothplate, or characters believed to be homologous with a toothplate. Notable among such forms are the families Buliminidae, Virgulinidae, Ceratobuliminidae and Cibicididae. The Cibicididae are found in most classifications in the families Rotaliidae or Anomalinidae, both of which typically have laminated shell material and thickening added to the test by it. The Cibicididae do not have obvious toothplates, but the homologies of their tests are satisfactorily treated only by reference to the concept of the toothplate foraminifera. Some of the genera that are to be associated with the *Dentata* but that do not have obvious toothplates are *Cibicides*, *Stenosiöina*, *Pseudovalvulineria*, *Gyroidina*, *Alabamina*, *Gyroidinoides*, and *Karrerina*.

*Begia* has a trochoid test with a flat top and a deep venter, recalling the shape of typical species of *Cibicides*; it has an inframarginal sulcus like that of *Alabamina*, and a buliminid aperture. The chamber walls are thin and unthickened. There is an internal toothplate. *Begia* is similar in many ways to *Ceratobulimina*, and is therefore classified in the family Ceratobuliminidae. It differs from *Ceratobulimina* in general shape and in the exact position of the toothplate.

A new family, the Barkerinidae, is proposed for the genera *Barkerina*, *Rabanitina* and *Coxites*. In these three genera the toothplate is very complex, and this distinguishes them from the other *Dentata*. *Coxites* is otherwise a typical trochoid form of the group; *Rabanitina* has a juvenile stage exactly like *Begia* excepting that the later chambers have a more complex toothplate, but the adult stage has chambers that are involute on both the dorsal and the ventral sides. *Barkerina* is planispiral throughout and has a structure like that of the adult stage of *Rabanitina*. The associations of the four genera with each other are so obvious, and their differences from other foraminifera so striking, that some taxonomic association is inevitable in spite of the remarkable differences between them. *Barkerina* occurs in the Albian, *Rabanitina* in the Cenomanian, and *Coxites* in the lower Turonian. *Begia* is best known in the lower Turonian but prob-

ably also occurs much lower. The assumption that there is a phyletic sequence between these genera involves either the derivation of simple from complex forms, which certainly does occur in the *Dentata*, or the further assumption that there are a number of "missing links." Possibly the stratigraphic ranges of the genera are longer than is known at present.

Genera such as *Gyroidina* and *Alabamina* may be derived from *Begia*. In *Gyroidina* the finely perforate wall is usually more opaque than is typical of the Buliminidae, but it does not seem similar to those of the Rotaliidae or Discorbidae. In section it often appears to be triple, with a dark layer between two lighter ones. The shape is beigiid: a simple spire with a flat top and a more or less conical venter. There is no toothplate, and the aperture is interiomarginal. In general, the shell material of *Barkerina* and *Rabanitina* resembles that of *Gyroidina*, and suggestions of triple structure have been seen in *Rabanitina*. *Gyroidina* has a recorded range from Lower Cretaceous to Holocene, but this cannot be substantiated below the Turonian on the basis of published records. Dr. E. Schijfsma, in a personal communication, has stated that *Gyroidina* occurs as early as the Barremian, and he showed the author specimens that might, but probably do not, belong to *Gyroidina*.

The two ostensible Lower Cretaceous species of *Gyroidina* require comment. *Rotalina nitida* Reuss, 1844, was referred to *Gyroidina* by Brotzen (1936), who later transferred it to *Gyroidinoides* Brotzen, 1942. Plummer's record of *Gyroidina nitida* (Reuss) from the Albian of Texas (1931) was renamed *Gyroidina loetterlei* Tappan, 1940, and was later transferred to *Valvulineria* by Loeblich (1946). *Gyroidina caracolla* Roemer, 1841, from the Lower Cretaceous of Germany, is an *Epistomina*. This leaves *Gyroidina micheliniana* d'Orbigny, 1826, Turonian and Senonian, as the oldest published species, and possibly the oldest in fact. This compares with the Cenomanian-Turonian age of *Begia*, and it is possible that not only *Gyroidina micheliniana* but all true species of *Gyroidina* trace their ancestry to *Begia*.

Brotzen (1942, p. 31) placed *Gyroidina micheliniana* in the new genus *Globorotalites* and suggested a phylogenetic origin that is inconsistent with the present hypothesis. The other species of *Globorotalites* seem rather different in shell texture and have a keel. Their close relationship to *Gyroidina micheliniana* is open to question.

The toothplate of *Begia* conforms to the rule formulated by Hofker (1951a, p. 355), that the toothplates of primitive older species of the Ceratobuliminidae



tend to be larger than those of more advanced species. The internal partitions in *Rabanitina* and *Barkerina* have the appearance of being formed by a single twisted, buttressed and perforated toothplate. This contrasts with the individual subepidermal partitions and buttresses found in complex Peneroplidae and with the tubulated mass of endoskeleton that is seen in most of the Alveolinidae. So far as is known, *Barkerina* (upper Albian) is the oldest genus, *Rabanitina* (lower Cenomanian) is intermediate in age, and the indubitable records of *Begia* are upper Cenomanian to lower Turonian. Only small, trochoid genera are known subsequently, and these are mostly without toothplates, e.g., *Cibicides*, *Gyroidina* and *Stensiöina*. *Coxites* (lower Turonian) has the flat-topped trochoid shape of *Begia*, but the internal partitions of the chambers are unique. Adequate proof that the partitions are derived from the toothplate of *Begia* is lacking, but no other explanation of their homologies seems probable. Although inadequate knowledge of this group may be causing a false impression, it seems that the primitive species are involute with a very complex toothplate, and that evolution has proceeded by reduction of the toothplate and by loss of the involute character dorsally, all new features appearing first in the juvenile stage and gradually becoming transferred to later stages of growth. This reversal of the usual law that ontogeny recapitulates phylogeny is not unprecedented in the animal kingdom.

#### SYSTEMATIC DESCRIPTIONS

##### Family Ceratobuliminidae

On the basis of the extensive recent work on the Ceratobuliminidae, notably by Hofker (1951a,b, 1954a,b,) and by Troelsen (1954), it is evident that the characteristic features of the family Ceratobuliminidae are the thin, hyaline, finely perforate wall, without obvious thickening; simple trochoid coiling; possession of an aperture of buliminid type (Glaessner, 1945, text-fig. 31); and an internal toothplate. The Ceratobuliminidae form a family distinct from the Buliminidae on account of the short axis of coiling; indeed, the marked asymmetry of the test often results more from the chamber shape than from the elongation of the axis of coiling. Hofker is inclined to regard the toothplate as an essential character of the Ceratobuliminidae.

The new genus *Begia* has a trochoid test with a flat dorsal surface and a more or less conical ventral surface. It therefore has an appearance that differs markedly from that of most of the Ceratobuliminidae. The organisation is nevertheless very closely in agreement with that of *Ceratobulimina*. So far as defective preservation permits observation, the nature of the shell wall is the same in both genera. In both, the chambers are added in a simple, definitely

asymmetrical spire that nevertheless shows little tendency to depart from the planispiral form, the trochoid habit being the effect of asymmetry of the chamber shape. The foramen of *Begia* is closely similar to, although not identical with, that of *Ceratobulimina*, and there is a buliminid toothplate, again differing in minor details from that of *Ceratobulimina*.

##### Genus *Begia* Smout, new genus

*Type species: Begia gyra* Smout, sp. nov.

This genus was first discovered by P. T. Cox in 1929 at Khaver Begi, Laristan, Iran, and was given the manuscript name *Begia* by him. (The correct pronunciation is "Beggia," with the "g" pronounced hard.) That locality has not been given for any of the species described here, however, because the specimens were seen only in thin sections of hard limestone, and cannot be completely described.

The test is composed of granular calcite, possibly originally finely perforate. The chambers are arranged in a simple spire, and are evolute dorsally and involute ventrally. The external shape is usually flat-topped, with a subacute margin and conical ventral side. The aperture is wholly ventral, a large interiomarginal slit with a large tooth attached to the septum. There is a marginal prolongation of each chamber and a corresponding inframarginal sulcus on the apertural face; the ventral part of the septum is nearly radial.

There is a small, thin, narrow internal plate in each chamber. It runs from the septum to the previous septum and often touches the external wall of the chamber, on which it usually shows as a slight kink in the septal sutures. In sub-equatorial sections cut at the appropriate level, the plate causes the septa to appear forked. A section near the dorsal surface cuts the marginal prolongations and shows a spire with much more inclined septa than do the deeper sections.

*Begia* has characters that are in very close agreement with those of *Ceratobulimina* Toulou, 1915, as emended by Finlay (1939). The obvious external difference is that *Begia* has a subacute to acute margin, whereas species of *Ceratobulimina* have distinctly rounded margins. The shapes of the chambers and spire in other respects are very similar in the two genera. *Begia* has either a sutural or a toothed aperture, while most species of *Ceratobulimina* have a virguline aperture. Since all three fall within the range of variation of the simpler buliminid apertures, the character is not considered a diagnostic one. The internal plate in the chambers of *Begia* corresponds well with the toothplate of *Ceratobulimina*. It is somewhat simpler in shape than that of *Ceratobulimina contraria* (Reuss) (fide Hofker, 1954a), the Holocene type species of *Ceratobulimina*, but it has already been noted by Hofker (1951a) that the Cretaceous species have simpler toothplates. Troelsen's contention that the toothplate of Cretaceous and Paleocene species is not attached to the dorsal wall, as it is in later species, is questioned by Hofker (1954a). In

*Begia gyra* the toothplate has an attachment to the ventral wall, the difference probably being caused by the different external shape of the test, but it is not certain that a visible external suture is present in all species.

Some sections of *Reinholdella* Brotzen, 1948, closely resemble those of *Begia*, but *Reinholdella* has laminated thickening, which is never seen in *Begia*, and the toothplate is more complex than that of *Begia*. *Reinholdella* usually has a flat ventral surface and a low conical dorsal side, the reverse of the condition in *Begia*.



TEXT-FIGURE 1

*Begia gyra* Smout, n. sp., drawing of the exterior to show the aperture, inframarginal sulcus, and suture of the toothplates.

***Begia gyra* Smout, new species**  
Plate 1, figures 1-9; text-figure 1

**Description:** The test is composed of granular calcite, in which perforations have not been seen. The chambers are completely evolute dorsally and involute ventrally, arranged in a spire composed of about three whorls. The sutures are slightly depressed, the margin subacute, and there is a slight false umbilicus. The dorsal surface is approximately flat; the ventral surface varies from conical to convex, its depth being rather variable. The margin is slightly lobate because of the depressed sutures. The ventral sutures are straight, with a slight nick near the middle, and the ventral part of the septum is nearly radial. The septal sutures on the dorsal surface are more highly inclined, for there are marginal prolongations of the chambers. This chamber shape gives rise to an inframarginal sulcus similar to that of *Alabamina*. The aperture is a large sutural slit with a large tooth attached to the septum. It is therefore rather like that of *Valvulina*. There is a slight forward fold of the septum at the base of the apertural tooth. A thin, narrow toothplate runs from the septum near the lower part of the aperture to the previous septum, where it is attached near its junction with the outer surface, causing the nick in the ventral suture. The toothplate is oblique and slightly twisted. In sections, it is usually seen only in those that are cut parallel to the plane of the spire but nearer the ventral pole than the dorsal one. It usually

appears then as a forked septum. A section cut parallel to the same plane but near the dorsal surface shows no internal structure in the chambers, does not cut the aperture, and shows much more highly inclined septa. At first sight, such a section would be thought to belong to a different species.

**Dimensions:** Diameter 0.3 mm. to 1.2 mm. Height 0.2 mm. to 0.9 mm. Diameter of nucleoconch 0.04 mm. to 0.08 mm. There are about three whorls, with eight chambers in the last.

**Occurrence:** Type level and locality: Lower Turonian of Zubair, southern Iraq, in a deep borehole. Other occurrences: Lower Turonian of Kuh-i-Bingistan, Iran; lower Cenomanian of Ratawi and lower Turonian of Nahr Umr, southern Iraq, in deep boreholes.

**Depository:** Department of Geology, British Museum (Natural History), London (B.M.N.H.). Registration numbers: Holotype, P.42931. Figured specimens, P.42948-P.42950. Other specimens, P.42946.

**Remarks:** This is a rather variable species, which shows variation toward all the other species with the exception of *Begia concava* Smout, sp. nov. A case could be made for regarding these species as varieties of *Begia gyra*. In identifying *Begia gyra* it is important that the diagnostic generic characters should be observed. It may be confused with juvenile specimens of *Rabanitina basraensis* Smout, sp. nov., or with species of *Gyroidina* and *Eponides*.

***Begia conica* Smout, new species**  
Plate 1, figures 10-14

**Description:** The test is very like that of *Begia gyra*, but the sutures are not indented. The margin is therefore entire and acute, and the dorsal surface strictly flat. The ventral surface is conical, with little or no umbilicus. The marginal prolongation and inframarginal sulcus are weakly developed, and the aperture shows the presence of a tooth only by a small lobe at its upper end. The internal plate is very thin and narrow, and the external mark made by it is inconspicuous.

**Dimensions:** Diameter 0.3 mm. to 1.2 mm. Height 0.2 mm. to 0.8 mm. Diameter of nucleoconch 0.02 to 0.08 mm. There are two to three whorls, with eight chambers in the last.

**Occurrence:** Type level and locality: Lower Turonian of Zubair, southern Iraq, in a deep borehole. Other occurrences: Middle Cretaceous of Ratawi and Nahr Umr, southern Iraq, in deep boreholes; lower Turonian of Kuh-i-Bingistan, Iran.

**Depository:** B.M.N.H.; reg. nos. P.42932 (holotype), P.42951 (figured specimen).

**Remarks:** *Begia conica* intergrades with *Begia gyra*, with which it occurs in about the same abundance. It also intergrades with *Gyroidina micheliniana* (d'Orbigny), and it is quite possible that some records of *Gyroidina micheliniana* in Europe may prove to refer to *Begia conica*. There is practically no difference between the two species excepting the



generic characters of the internal plate, the aperture, and the inframarginal sulcus. In *Begia conica* these are all much reduced. *Gyroidina micheliniana* has traces of an inframarginal sulcus but no internal plate or apertural tooth. *Begia conica* is distinguished from the other species of the genus, with the exception of *Begia convexa*, by the lack of lobation of the chambers, particularly at the margin.

***Begia concava* Smout, new species**

Plate 1, figures 15-18

**Description:** The test is very smooth, with no depression of the sutures. The dorsal surface is strongly and very smoothly concave, the margin is acute, and the ventral surface is smoothly convex without an umbilicus. The internal plate is inconspicuous, and the marginal prolongations slight.

**Dimensions:** Diameter 0.5 mm. to 1.0 mm. Height 0.2 mm. to 0.7 mm. Diameter of nucleoconch about 0.08 mm. There are two to three whorls, with eight chambers in the last.

**Occurrence:** Type level and locality: Lower Turonian of Zubair, southern Iraq, in a deep borehole. Other occurrences: Lower Turonian of Kuh-i-Bingistan, Iran.

**Depository:** B.M.N.H.; reg. nos. P.42933 (holotype), P.42952 (figured specimen).

**Remarks:** This species is highly distinctive in its shape, and the convex dorsal surface is even more readily seen in thin section than in separate specimens. The specimens are much less numerous than those of *Begia gyra*.

***Begia calcarata* Smout, new species**

Plate 1, figures 23-25

**Description:** This species differs from *Begia gyra* only in the lobation of the margin. Each chamber is drawn out at the margin into a short, hollow point.

**Dimensions:** Diameter 0.6 mm. to 0.8 mm. Height 0.3 mm. to 0.5 mm. Diameter of nucleoconch 0.04 mm. to 0.08 mm. There are about three whorls, with eight chambers in the last.

**Occurrence:** Type level and locality: Lower Turonian of Zubair, southern Iraq, in a deep borehole.

**Depository:** B.M.N.H.; reg. no. P.42934 (holotype).

**Remarks:** Typical specimens differ markedly from the typical form of *Begia gyra*, but the latter species varies in the degree of lobation of the margin, and thereby intergrades with *Begia calcarata*. *Begia calcarata* is less abundant than *Begia gyra*.

***Begia perforata* Smout, new species**

Plate 1, figures 19-22

**Description:** The test is very like of *Begia gyra*, perhaps being less variable in shape and usually having a slightly

raised dorsal surface and a conical ventral one with a distinct false umbilicus. Its distinctive feature is the faint marking by punctae distributed evenly all over the surface. These form an apparent mesh with about 0.01 mm. spacing.

**Dimensions:** Diameter 0.3 mm. to 0.8 mm. Height 0.2 mm. to 0.7 mm. Diameter of proloculum 0.04 mm. to 0.08 mm. There are two or three whorls, with seven chambers in the last.

**Occurrence:** Type level and locality: Lower Turonian of Zubair, southern Iraq, in deep boreholes.

**Depository:** B.M.N.H.; reg. nos. P.42935 (holotype), P.42953 (figured specimen), P.42947 (other specimen).

**Remarks:** The test appears to have the same granular structure as the other species of *Begia*, and the generic characters are clearly shown. It seems probable that the punctations represent perforations, but the latter cannot be established with certainty. Alteration of the test in fossilisation would be expected to obliterate perforations if they were initially present. The complete lack of any trace of perforation in *Begia gyra* and other species may be the result of the initial absence of perforation, of the presence of smaller perforations than those of *Begia perforata*, or of more complete alteration of the test in *Begia gyra*. It is possible that the difference between *Begia gyra* and *Begia perforata* consists only of the manner of preservation.

***Begia convexa* Smout, new species**

Plate 1, figures 26-28

**Description:** Typical specimens differ sharply from the usual shape of species of *Begia* in having a convex or conical dorsal surface, with corresponding flattening of the ventral surface. The apertural face is consequently modified considerably in shape, but feebly shows the characters of *Begia*. There is usually a weakly punctate ornament like that of *Begia perforata*. The specimens are, on the average, much smaller than those of the other species.

**Dimensions:** Diameter 0.3 mm. to 0.6 mm. Height 0.2 mm. to 0.5 mm. There are about two whorls, with six chambers in the last.

**Occurrence:** Type level and locality: Lower Turonian of Zubair, southern Iraq, in a deep borehole. Other occurrences: Lower Turonian of Ratawi and Nahr Umr, southern Iraq, in deep boreholes.

**Depository:** B.M.N.H.; reg. no. P.42936 (holotype).

**Remarks:** This species is not typical of *Begia*, but does have the typical aperture and internal plate. It may represent deformed juvenile specimens of *Begia perforata*. A similar tendency for the earliest part of the test to have a raised dorsal surface is seen in some species of *Gyroidina*.

**Begia glomerulata** Smout, new species

Plate 1, figures 29-31

**Description:** The test is subglobular and very irregular in shape. Only the last whorl is visible externally, and it is multiple with two terminal chambers. The two spirals are not in the same plane, nor do they have the same orientation. The terminal chambers retain the shape of those of *Begia perforata*, showing an inframarginal sulcus. There is the same punctate ornament as in *Begia perforata*.

**Dimensions:** Diameter 0.8 mm. Height 0.7 mm.

**Occurrence:** Type level and locality: Lower Turonian of Zubair, southern Iraq, in a deep borehole.

**Depository:** B.M.N.H.; reg. no. P.42937 (holotype).

**Remarks:** There is only one undoubted specimen, although a few distorted specimens of *Begia* that might be similar have been seen in fragmentary condition. Probably this species is based on a monstrous specimen of *Begia perforata*, but it is so distinctive that it seems best to name it independently.

**Family Barkerinidae** Smout, new family

The test is conical or globular, sometimes changing abruptly from conical to globular. The shell material is probably granular, in some cases heavy, and the walls appear to have two layers separated by a thin parting. Arenaceous matter has not been seen in the wall of any species. The chambers are added in a plane spire and are either equitant or trochoid, in which case the dorsal surface is evolute. Trochoid chambers tend to have a marginal prolongation with an inframarginal sulcus. Apertural characters are inadequately known; they are suspected to vary from valvulinid to cribrate. There is always a complex internal toothplate. This may be a ribbon, variously twisted, with buttresses or internal partitions, but always with a marked longitudinal trend. The proximal ventral part of the chamber tends to be left as an empty canal. Perforations have not been proven to exist. If they do, they are very fine in all known species.

**KEY TO GENERA**

Test globular, involute throughout..... *Barkerina*  
 Test globular, initially trochoid..... *Rabanitina*  
 Test trochoid throughout..... *Coxites*

*Barkerina* and *Rabanitina* hardly differ, except that *Barkerina* is involute and bilaterally symmetrical throughout, whereas *Rabanitina* has a juvenile stage that is trochoid and very closely resembles *Begia*. *Coxites* is trochoid throughout, rather complanate, and has transverse partitions attached to the toothplate. It has little resemblance to *Barkerina*, but rather more to *Begia*. *Begia* has been placed in the Ceratobuliminidae because its differences from *Ceratobulimina* are slight, but the more complex

structures of the other three genera are not typical of the Ceratobuliminidae, and a new family is therefore proposed. The apparent relationship between the four genera, and their isolation from other foraminifera, justifies the association, although it must be admitted that the phyletic relationships are not as clear as could be wished. The inclusion of both involute and trochoid genera in a single family is unusual, but in this case the intermediate nature of *Rabanitina* makes it reasonable. The geologic succession, *Barkerina*—*Rabanitina*—*Coxites*, suggests evolution from the symmetrical to the trochoid condition, and reduction of the toothplate rather than elaboration of it. This fits in with the suggested evolution of *Gyroidina* from *Begia* at a still later date. *Begia*, however, probably has a longer range than the Barkerinidae, and could be a root stock for all three genera.

**Genus Coxites** Smout, new genus

**Type species:** *Coxites zubairensis* Smout, sp. nov.

This monotypic genus is named after P. T. Cox, who first investigated this group of foraminifera. The test is composed of thin, granular calcite, through which the internal structure can be seen. Perforations have not been observed. The dorsal surface is flat, the margin acute, and the ventral surface low conical. The chambers are evolute dorsally and involute ventrally, sometimes incompletely so in the last whorl. They have a very long marginal prolongation. The aperture has not been observed. There is an incomplete longitudinal plate in each chamber, running from roof to floor of the chamber. Usually it is oblique, so that it is attached to the middle of the ventral chamber wall, with a suture intermediate between two septa and parallel to them, but it may not appear on the dorsal surface, presumably because it is sometimes attached to the septum or dependent on transverse partitions rather than attached to the outer wall.

The internal partitions of *Coxites* are generally reminiscent of those of the Valvulinidae and the Peneroplidae, but are different in detail from those of either. The Valvulinidae have subepidermal chamberlets, some of the partitions of which are continued toward the axis as radial partitions. The Peneroplidae have simple transverse partitions without any longitudinal elements.

*Rabanitina* has a complex longitudinal plate, and it also has a flat-topped shape in the nepionic stage. There is therefore a strong reason for associating *Rabanitina* with *Coxites* as a possible ancestral form.

Two species have a general resemblance to *Coxites*: *Meandropsina vidali* Schlumberger, 1898, and *Dictyopsella chalmasi* Schlumberger, 1900. *Meandropsina* is bilaterally involute, but its lateral appearance is very like that of the ventral side of *Coxites*. The only striking difference is the longitudinal component of the partitions in *Coxites*. *Meandropsina vidali* is supposed to be porcellaneous, whereas

*Coxites* is supposed to be granular, but in neither case is the composition of the wall established beyond all doubt. In all probability, the resemblances between *Coxites* and *Meandropsina* are superficial and do not indicate close relationship. *Dictyopsella* is a compressed trochoid form with granular shell material in which some arenaceous matter is incorporated. It is flat-based rather than flat-topped, and the chambers are reniform rather than alate. Its internal partitions consist of subepidermal partitions, the primary plates of which are continued toward the axis. Again, the resemblances to *Coxites* can be dismissed as superficial.

Among the Dentata, the toothplate is the only internal structure that resembles a longitudinal plate within the chambers. *Coxites* has the marginal prolongations much longer than they are in *Begia*, and this would draw out the toothplate in the manner seen. The development of transverse partitions attached to it is unprecedented, but not out of keeping as a variation of the complexities seen in *Rabanitina*, *Bitubulogenerina* and *Cushmanella*. Perforations have not been observed, but fine ones may be present.

#### *Coxites zubairensis* Smout, new species

Plate 2, figures 1-6

**Description:** The test is trochoid but so flat as to be almost discoidal. The dorsal surface is flat, the margin entire and subacute, and the ventral surface conical with a distinct false umbilicus of variable size. The shell material is thin, transparent, and yellowish in colour. It was probably originally granular. Perforations have not been seen. There is no arenaceous matter incorporated in the test. The dorsal surface is smooth, with flush sutures that are nevertheless clearly visible. The septal sutures are strongly curved and the chambers narrow. Transverse partitions, usually simple but sometimes forked, are seen along all the chambers, and they are present even in the earliest one. Traces of a longitudinal partition are rarely seen. Ventrally the septal sutures are slightly indented, and the chambers may be slightly swollen near the ventral pole. Usually there is a small false umbilicus, but in large specimens the ventral limbs of the chambers shorten markedly in the last whorl. The ventral sutures are curved, although not as much as the dorsal ones. The unbroken apertural face has not been observed, but there are indications that it had a distinct marginal sulcus, and there is a possibility that the aperture was like that of *Begia*. The longitudinal partition is usually clearly seen on the ventral surface, and is parallel to the septa. It usually disappears near the margin. The transverse partitions are only occasionally seen distally to this partition, but are conspicuous in the proximal part of the chamber. The nucleocoenoch appears bicellular, and is succeeded directly by a chamber that is normal. There is no trace of a polar mamelon or pit in well preserved specimens.

**Dimensions:** Diameter 0.7 mm. to 1.4 mm. Height 0.2 mm. to 0.4 mm. Diameter of proloculum 0.13 mm. to 0.2 mm. There are about three whorls in a large specimen, with

twelve to sixteen chambers in the last whorl. There are about eighteen transverse partitions in the later chambers.

**Occurrence:** Type level and locality: Lower Turonian of Zubair, southern Iraq, in a deep borehole.

**Depository:** B.M.N.H.; reg. nos. P.42937 (holotype), P.42952, P.42954 (figured specimens), P.42940-P.42945 (other specimens).

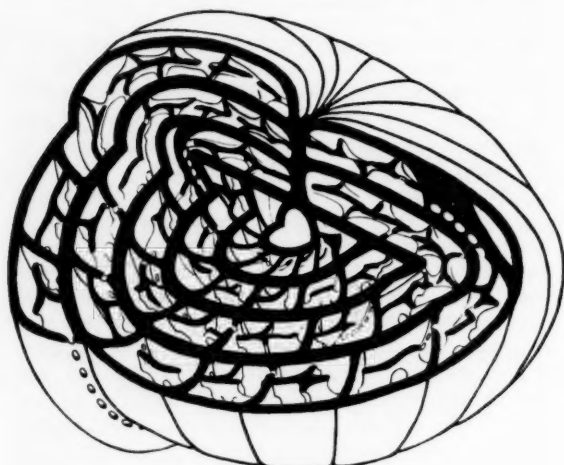
#### Genus *Rabanitina* Smout, new genus

**Type species:** *Rabanitina basraensis* Smout, sp. nov.

This monotypic genus is named after Mr. P. Rabanit, who collected most of the specimens. The shell material appears to be granular calcite without arenaceous matter. Perforations have not been observed. The test is subspherical in the adult, there being a slight asymmetry of the poles. In the young, it is trochoid with a flat top, a subacute margin, and a conical ventral surface with a slight ventral false umbilicus. The sutures are flush or slightly indented. The septa are nearly radial. The aperture has not been observed with certainty. In the adult chambers, and in all but the earliest juvenile ones, there is a complex longitudinal plate. It is twisted and has rows of large holes, but is substantially parallel to the spiral wall of the chamber. It is buttressed to floor and roof. The change from the trochoid to the globular habit is abrupt. The juvenile chambers are completely evolute dorsally, and the later ones are involute. The acute margin is gradually lost, until the test could be taken for that of a globular alveoline or fusuline species.

*Barkerina* Frizzell and Schwartz, 1950, has a strong general resemblance to *Rabanitina*, and although *Barkerina barkerensis* Frizzell and Schwartz, 1950, is specifically distinct from *Rabanitina basraensis*, they may be congeneric. The published description of *Barkerina barkerensis* appears, after examination of topotypes kindly sent by Dr. Frizzell, to be as accurate as can be achieved. As Maync (1952) has noted, the shell material of *Barkerina barkerensis* is not arenaceous. It is almost certainly granular. Maync is probably correct in rejecting *Cribristomoides trinitatis* Cushman and Jarvis, 1928, and *Cribristomoides cretacea* Cushman and Goudkoff, 1944, as species of *Barkerina*. Maync does not believe that *Barkerina* is a genus of the Lituolidae. It is indeed a very anomalous genus in that family, but short of the creation of a new family, which is now proposed, it is hard to see where else Frizzell and Schwartz could have placed it. The exact structure of *Barkerina* is difficult to observe and is not known in the same detail as that of *Rabanitina*. There is no trace of a trochoid nepionic stage, the test being planispiral and involute throughout. The chambers appear to agree very closely with the adult chambers of *Rabanitina*. The trochoid nepionic stage is therefore the diagnostic character by which *Rabanitina* is distinguished from *Barkerina*.

The trochoid juvenile test of *Rabanitina* strongly resembles that of *Begia conica*. It reaches a maximum size slightly larger than that of *Begia conica* before involute chambers are produced. The very early chambers may have a structure that is identical with that of *Begia*, but after the first few chambers, the complex plate of *Rabanitina* can be seen, although it does not reach its full development until about the end of the first whorl. *Rabanitina* is therefore distinguished from *Begia* by the adult involute stage and the nature of the internal plate, but juvenile specimens can be mistaken for *Begia*.



TEXT-FIGURE 2

*Rabanitina basraensis* Smout, n. sp., block diagram to show the relationship between the equatorial and axial sections.

#### *Rabanitina basraensis* Smout, new species

Plate 1, figure 32; plate 2, figures 7-22; text-figure 2

**Description:** The test is subspherical in the adult and resembles a slightly distorted globular species of the Fusulinidae or Alveolinidae. The shell material is porcelainous, and no perforations have been seen. The chambers are arranged in a simple spire and are shaped like those of *Alveolina*. There is a slight asymmetry between the two poles. The aperture is a single or double row of pores on the terminal face. Inside each chamber there is a plate, roughly parallel to the roof of the chamber, and this has two or three rows of large holes, at the margins of which buttresses run to the roof and floor of the chamber.

The nepionic test is trochoid, the dorsal surface being flat and strictly evolute, and the ventral side sharply conical with a small false umbilicus. The earliest chambers appear to be empty, but in the first whorl a small plate appears over the aperture; the plate increases in size and complexity so that the later nepionic chambers have the same internal structure as the ephebic ones. The evolute dorsal surface is hidden by the involute ephebic chambers, which

succeed the nepionic ones abruptly. The asymmetry of the adult test is a result of the shape of the nepionic test, and is almost obliterated so far as external appearance goes in large specimens. In equatorial section no break between nepionic and ephebic chambers can be seen, but in slightly oblique and axial sections the abrupt change of habit cannot be overlooked. The proloculum is spherical and is succeeded directly by a normal chamber. No dimorphism has been observed.

As found, the specimens are separate but usually decorticated, and the shell material is altered. In thin section the septa sometimes appear triple, as they do in the Miliolidae and Alveolinidae. The shell material obviously forms a complete wall for each chamber, and does not thicken older parts of the test. There is no exterior ornamentation, but a perfect specimen faintly shows the sutures of the last whorl.

**Dimensions:** Equatorial diameter 0.8 mm. to 2.1 mm. Axial length 0.7 mm. to 1.6 mm. Diameter of nucleocoenoch 0.09 mm. to 0.15 mm. There are about two and one-half nepionic whorls and about three ephebic ones, with nine chambers in the first whorl, twelve in the second, and about sixteen in each of the succeeding whorls.

**Occurrence:** This species is known only from a lower Cenomanian limestone in the Zubair oil field, southern Iraq, in deep boreholes.

**Depository:** B.M.N.H.; reg. nos. P.42957 (holotype), P.42958-P.42965 (figured specimens), P.42966 (other specimens).

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## EXPLANATION OF PLATES

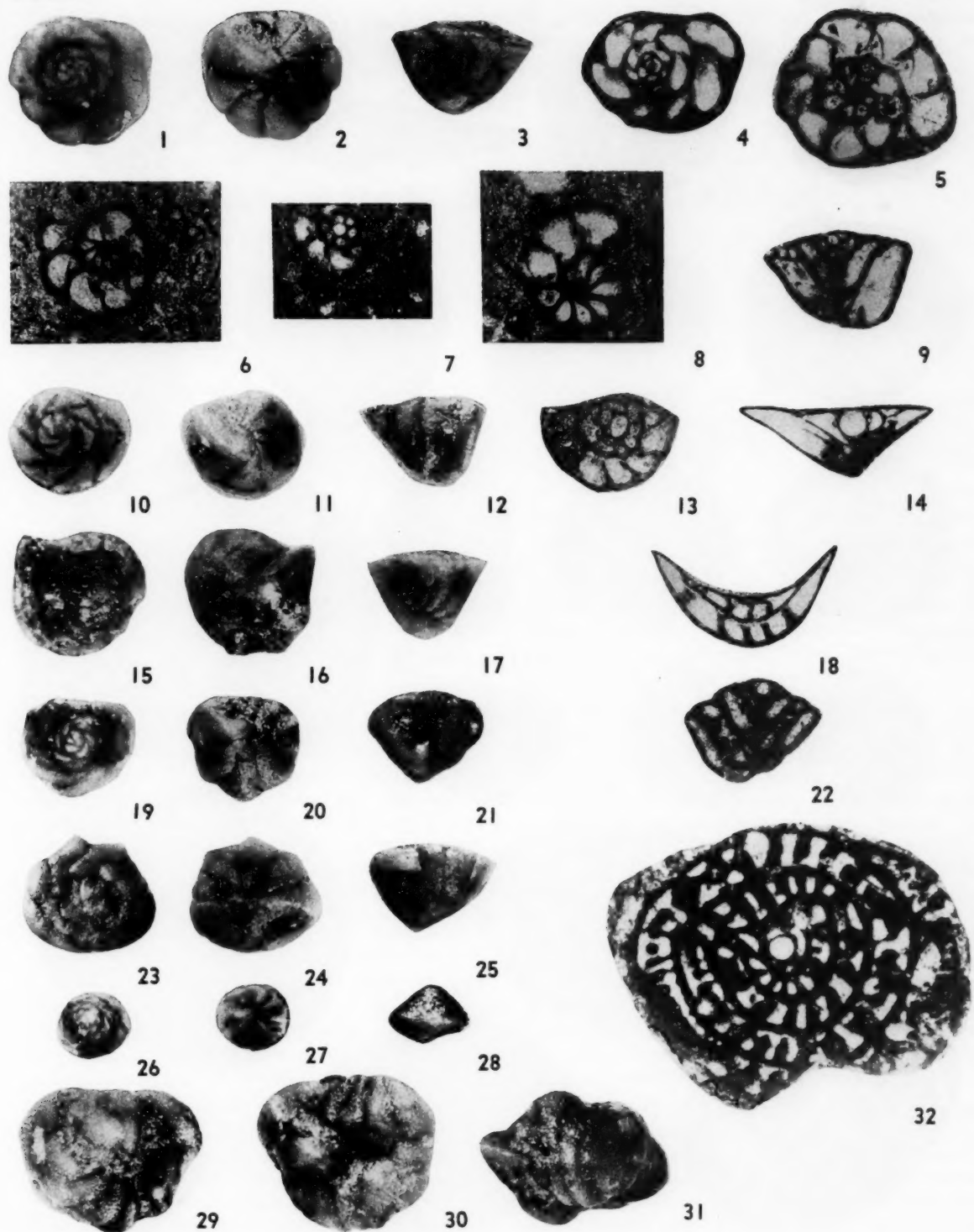
## PLATE 1

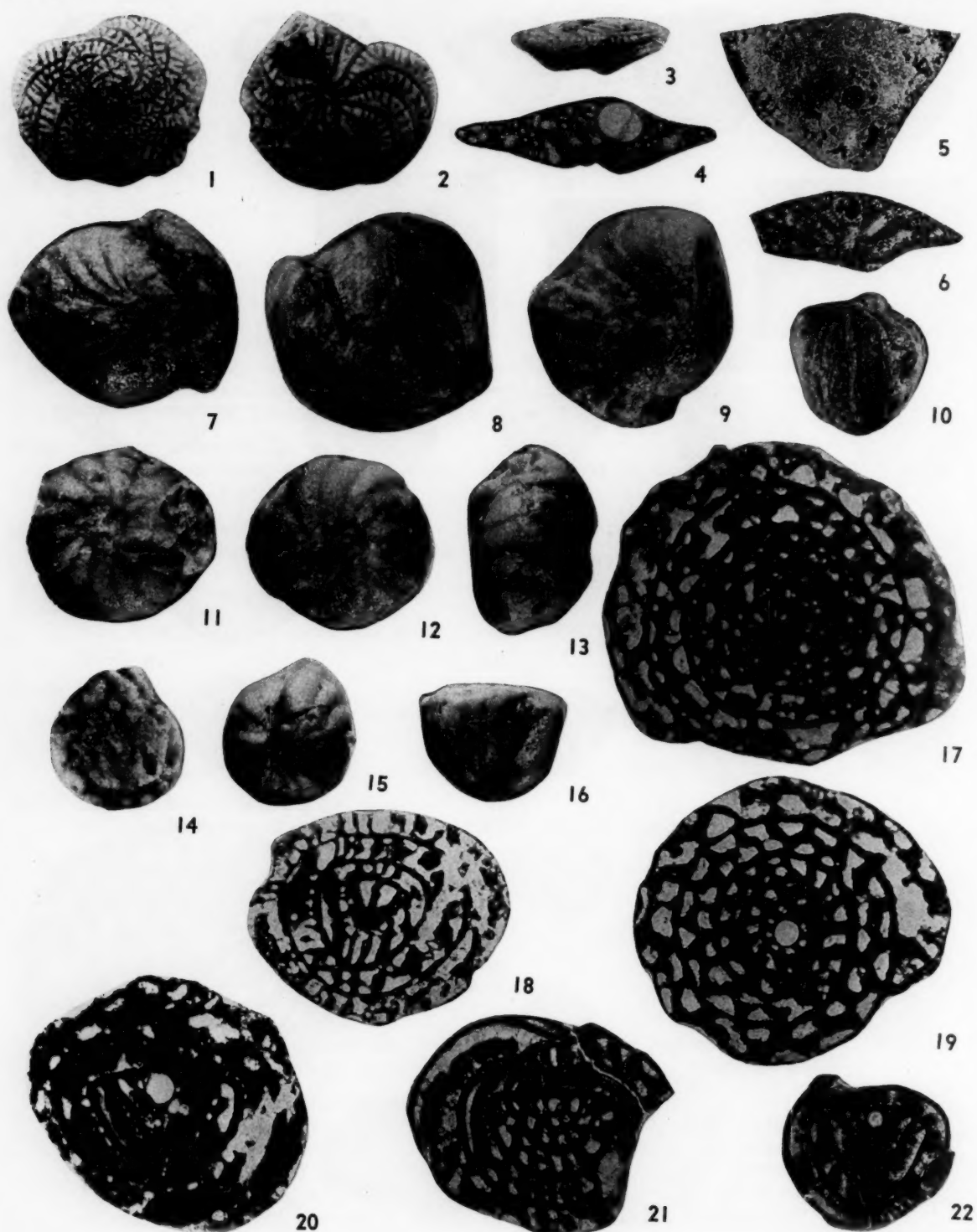
All figures  $\times 40$ 

- 1-9 *Begia gyra* Smout, n. sp.  
1-3, holotype, dorsal, ventral and apertural views; reg. no. P.42931. 4, horizontal section through margin; P.42948. 5, horizontal section showing toothplates; P.42949(i). 6-8, random sections; P.42950. 9, axial section; P.42949(ii). Turonian; Zubair.
- 10-14 *Begia conica* Smout, n. sp.  
10-12, holotype, dorsal, ventral and apertural views; P.42932. 13, oblique section; P.42951. 14, axial section; P.42951. Turonian; Zubair.
- 15-18 *Begia concava* Smout, n. sp.  
15-17, holotype, dorsal, ventral and apertural views; P.42933. 18, random section; P.42952(i). Turonian; Zubair.
- 19-22 *Begia perforata* Smout, n. sp.  
19-21, holotype, dorsal, ventral and apertural views; P.42935. 22, random section; P.42953. Turonian; Zubair.
- 23-25 *Begia calcarata* Smout, n. sp.  
Holotype, dorsal, ventral and lateral views; P.42934. Turonian; Zubair.
- 26-28 *Begia convexa* Smout, n. sp.  
Holotype, dorsal, ventral and apertural views; P.42936. Turonian; Zubair.
- 29-31 *Begia glomerulata* Smout, n. sp.  
Holotype, dorsal, ventral and apertural views; P.42937. Turonian; Zubair.
- 32 *Rabanitina basraensis* Smout, n. sp.  
Nearly axial section; P.42955. Cenomanian; Zubair.

## PLATE 2

- 1-6 *Coxites zubairensis* Smout, n. sp.  
1-2, holotype, dorsal and ventral views; P.42937. 3, apertural view; P.42954. 4, axial section; P.42952(ii). 5, equatorial section; P.42954(i). 6, axial section; P.42954(ii). Turonian; Zubair. All  $\times 40$ .
- 7-22 *Rabanitina basraensis* Smout, n. sp.  
7-9, holotype, dorsal, ventral and marginal views; P.42957. 10, marginal view of a decorticated specimen; P.42959. 11-13, dorsal, ventral and marginal views; P.42958. 14-16, juvenile specimen, dorsal, ventral and marginal views; P.42960. 17, subequatorial section, lower than that of fig. 19; P.42965. 18, oblique section; P.42962. 19, subequatorial section; P.42964. 20, random section; P.42956. 21, nearly axial section; P.42963. 22, axial section; P.42961. Cenomanian; Zubair. All  $\times 30$  except fig. 20, which is  $\times 40$ .





**ABSTRACT:** Miocene beds are described and their stratigraphic position discussed on the basis of the foraminifera contained. *Taberina malabarica* (Carter) (*Orbiculina malabarica* (Carter) of authors) is considered to be Burdigalian in age. Beds younger than Burdigalian are not present. The fauna shows Indo-Pacific affinities.

## Stratigraphy of the Miocene beds of Kathiawar, western India

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### INTRODUCTION

The richly fossiliferous Miocene beds of Kathiawar, in the State of Saurashtra, have long been known to Indian geologists. As early as 1884, Fedden gave an account of these beds, but since then little has been added to our knowledge of the Tertiary geology of Kathiawar.

The present work was started five years ago, when the authors were appointed research students under the direction of Professor S. R. N. Rao. The geological observations on which the following account is based were made during 1952, 1953 and 1954, when field work was undertaken in Kathiawar for the purpose of mapping and making collections. The area around Bhatia (lat. 22°06' N., long. 69°16' E.) and Bhogat (lat. 21°59' N., long. 69°14' E.), on the western coast, was selected for detailed mapping because good sections of foraminiferal beds are exposed in an almost continuous sequence in this locality. A traverse was made eastward along the coast as far as Bhavnagar, and all important exposures were examined. Systematic collections were made from all important fossil localities.

The authors take this opportunity to express their indebtedness to Professor S. R. N. Rao for his invaluable guidance. Dr. S. B. Bhatia collaborated with Mohan in identifying the smaller foraminifera.

In 1853 Carter recorded, and in 1861 he described, what he called a "small variety of *Orbiculina malabarica* (Carter)" from beds near Porbander. Duncan and Sladen (1883) described fossil Echinoidea from beds near Okha Mandal, in western Kathiawar, which

Blanford (1883) regarded as Miocene and believed to be equivalent to the Gaj beds of Sind. The first official survey was carried out by Fedden (1884), who gave a systematic account in his memoir on the geology of Kathiawar. Because this account forms the basis of our work in Kathiawar, Fedden's main stratigraphic conclusions are summarized below. The formations recognized by Fedden are shown in Table 1.

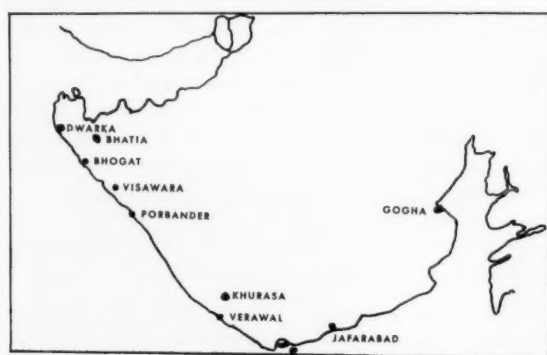
It should be noted that no Nummulitic limestones are mentioned in Table 1. Regarding the reported occurrence of Nummulitic limestones, Fedden states (1884, p. 5): "I may here mention that no such rock has been met with by me in this province. None of the Tertiary rocks exposed can be of earlier age than Miocene." He refers (1884, p. 50) to this point again when discussing the foraminifera found near Bhogat: "Certain of the beds exposed in a few places in the neighbourhood of Bhogat . . . contain small foraminifera and other organisms, among them a *Conulites* (or *Patellina*?), which is not unlike a nummulite in shape, though differing in structure; and very probably the discovery of this foraminifer gave rise to the presumption that rocks of Nummulitic age had been found in the province." The present work has established that Fedden's "*Conulites*" is not a nummulite but a *Lepidocyclina*.

Since Fedden's pioneer work in 1884, the Tertiary rocks of Kathiawar have attracted very little attention. Ghosh (1935) and Dunn (1942) visited the eastern part of the Peninsula to make investigations in connection with the occurrence of natural gas, which was found in wells near Gogha.



TABLE 1

FORMATIONS	APPROXIMATE AGE (FEDDEN, 1884)	AGE ACCORDING TO LATER WORKERS
Alluvium	Recent and sub-Recent	Recent
Sand dunes, tidal flats, fresh-water alluvium, "Ran" clays, raised beaches and miliolites		Sub-Recent
Dwarka beds (cream-coloured freestones consisting of calcareous wind-blown sandstone)	Higher Tertiary, of post-Pliocene age?	Pleistocene
Gaj beds (brown to buff or yellow limestones, marls and calcareous sandstones)	Upper Miocene — Manchar (in part) and Gaj of Sind	Burdigalian (Mohan, 1954, and Chatterji, 1955)
Lateritic rocks	Lower Eocene?	
Traps	Cretaceous or Eocene (Deccan traps)	Palaeocene
Trappean grits	Cretaceous?	
Wadhawan sandstones (beds containing mainly sandstones, limestones, and cherts, which are fos- siliferous)	Cretaceous? (infra-trappeans of Peninsular India)	Upper Cretaceous, equivalents of Bagh beds
Umia beds (bedded sandstone 1000' thick; lower part contains plant remains in carbonaceous matter; upper part contains cycads and conifers resembling the flora of the Umia beds of Kutch)	Jurassic (upper Gondwana)	Lower Cretaceous



TEXT-FIGURE 1

SKETCH MAP OF KATHIAWAR SHOWING IMPORTANT  
FOSSIL LOCALITIES

#### THE MIOCENE BEDS

The Miocene formations lie on the denuded edges of the traps. They occupy a narrow belt not more than 12 miles in width along the coastline in the southeastern, southern and southwestern parts of the Peninsula. They occur in small isolated patches from Bhavnagar in the east to Okha Mandal in the west. The exposures, which have maximum thicknesses of 40 to 59 feet, are located in the nala sections and creeks. The beds are nearly horizontal, but often have a slight dip toward the coast. No evidence of folding or faulting has been observed. The aggregate thickness is estimated to be several hundred feet. Important localities in the area are shown in text-figure 1.

The Miocene exposures in Kathiawar are as follows:

## MIOCENE OF WESTERN INDIA

### Southeast coast

Near Bhavnagar, the rocks are found to occur very sparsely in the alluvium. The Miocene rocks here are agatiferous, and resemble the agate conglomerates (Burdigalian) of the Surat-Broach region.

The Gogha exposures described by Dunn (1942) are exposed in a stream west of Bhuteshwar (lat.  $21^{\circ}40'$  N., long.  $72^{\circ}15'$  E.), and dip gently toward the north-west. A measured section showed the following sequence of beds (in descending order):

- 3 - Shaly limestones with small agates, passing upward into alluvium
- 2 - Calcareous grits ..... 1 foot
- 1 - Highly friable sandstones and clays .... 3 to 5 feet

The calcareous grits (unit 2) are fossiliferous, and contain *Miogypsina* cf. *antillea*, *Rotalia* sp., and *Operculina* sp. The fauna indicates a Burdigalian age. The beds were produced by the same Miocene transgression that gave rise to the agate conglomerates of the Tapti-Narbada region.

### Southern coast

Along the coast southward from Gogha, the following beds are found:

**Mitiwari area:** The rocks exposed here consist of rusty brown, hard, gritty sandstones with annelid tubes.

**Kagwadar area:** Along a stream passing through Kagwadar and meeting the sea 6 miles north of Jaferabad, marly limestones containing Zoantharia, Bryozoa, Lamellibranchia and Gastropoda are exposed. The most important exposure is an inlier 3 to 4 miles in extent near Wasawar. Here the rocks are yellow shaly limestones in which *Pecten corneus* Sowerby is present.

**Verawal area:** A large exposure of Miocene rocks occurs some 12 miles north-northwest of this town, which is on the seacoast. These rocks consist of yellow argillaceous limestones filled with fragmental fossils difficult to identify. At Khorasa (lat.  $21^{\circ}03'$  N., long.  $70^{\circ}20'$  E.), east of Chorward, the rock is a hard, tough marly limestone, buff-coloured and containing numerous fragmental bryozoans and corals. A collection was made in a newly dug well  $1\frac{1}{2}$  miles west of Khorasa village. The well section (in descending order) is as follows:

- 3 - Dwarka beds and miliolites ... light, buff-coloured porous limestones
- 2 - Miocene beds ..... yellowish clay marl and yellowish foraminiferal limestones
- 1 - Traps

The Miocene rocks of this locality have proved to be the richest in well-preserved foraminiferal assemblages, and contain the well-known species *Taberina malabarica* (Carter) (= *Orbiculina malabarica* (Carter) of authors). The following foraminiferal genera have been recorded from these beds: *Ammodiscus*, *Glomospira*, *Textularia*, *Clavulina*, *Quinqueloculina*, *Spiroloculina*, *Triloculina*, *Austrotrillina*, *Pyrgo*, *Globulina*, *Nonion*, *Elphidium*, *Operculina*, *Heterostegina*, *Taberina*, *Archaias*, *Sorites*, *Trifarina*, *Gemmaricella*, *Bolivina*, *Discorbis*, *Valvulinaria*, *Rotalia*, *Asterigerina*, *Globigerina*, *Anomalina*, *Cibicides*, *Gypsina*, *Nephrolepidina*, *Tryblionella*, *Miogypsina* s.s., and *Lepidosemicyclina*.

### Southwestern coast

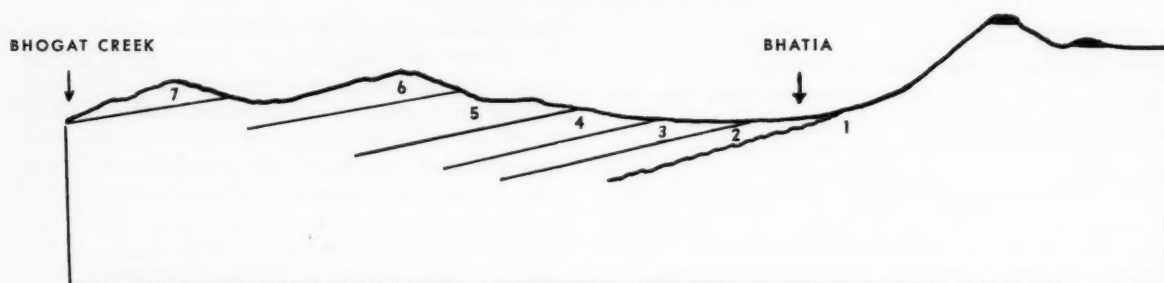
**Porbander area:** Much of the coastal region between Verawal and Porbander is covered with alluvium. Near Porbander, outcrops of Miocene rocks are found for a distance of about 17 miles along the coast. Here the boundary between the traps and the Miocene rocks is concealed by thick beds of laterite, alluvium and miliolites.

### Western coast

**Visawara area:** Near Visawara (lat.  $21^{\circ}47'$  N., long.  $69^{\circ}27'$  E.), 6 miles south of Miani Creek, small patches of weathered Miocene rocks occur. They are full of fossils, and have yielded numerous specimens of Cephalopoda (*Sepia*), Gastropoda, Lamellibranchia, Bryozoa, Crustacea, and Echinodermata, together with a rich foraminiferal assemblage. The following foraminiferal genera have been recorded from this locality: *Textularia*, *Clavulina*, *Quinqueloculina*, *Austrotrillina*, *Lagena*, *Elphidium*, *Discorbis*, *Rotalia*, *Cibicides*, *Gypsina*, *Nephrolepidina*, *Miogypsina* s.s., and *Lepidosemicyclina*. *Tryblionella* and *Taberina malabarica* (Carter) are absent here, and the fauna as a whole is distinct from, and older than, that recorded from the "Orbiculina"-bearing beds of Verawal and Bhogat.

North of Visawara, the traps extend right up to the coast, and in places are covered by the miliolites. A large exposure of Miocene rocks extends from Halar to Okha Mandal in the north. A large part of Okha Mandal is covered by the miliolites, on the western borders of which a few Miocene outcrops occur.

**Bhatia-Bhogat area:** The formations exposed in this area are shown in text-figure 2. Near the village of Bhatia (lat.  $22^{\circ}06'$  N., long.  $69^{\circ}16'$  E.), the boundary between the traps and the Miocene rocks is marked by a thick covering of laterite. The boundary runs in a northwest-southeast direction, changing to north-south



TEXT-FIGURE 2

GENERALIZED SECTION FROM BHOGAT CREEK TO BHATIA VILLAGE

Formations in descending order: 7, debris and Recent; 6, Dwarka and miliolite beds; 5, *Ostrea* beds; 4, *Orbiculina* beds; 3, gritty zone; 2, *Miogypsina* beds; 1, traps.

a few miles north of Bhatia (see text-fig. 3). The Miocene rocks are much darker in colour than elsewhere, and are highly impregnated with iron oxide derived from the laterites. About one and one-half furlongs north and about one-half mile east of the Bhatia railway station, a buff-coloured limestone is exposed. It has yielded *Quinqueloculina*, *Spiroloculina*, *Elphidium*, *Rotalia*, and *Miogypsina* s.s. These beds are designated the **Bhatia limestone**.

About one and one-half miles northeast of Bhatia village, Miocene rocks are exposed in a gypsum quarry. They contain *Taberina malabarica* (Carter), and are younger than the Bhatia limestone.

A little south of Bhatia village, near the village of Harmatia, a stream runs southwestward into Bhogat Creek. A good section is exposed in this stream; from Harmatia to Bhogat village (lat. 21°59' N., long. 69°14' E.), a complete sequence of the Miocene and post-Miocene beds known in Kathiawar is exposed, younger and younger rocks outcropping downstream toward the seacoast. The beds show a gentle dip (less than 5°) toward the coast. About one and one-half miles N. 34° E. from Bhogat village, in the bed of this stream, the following descending sequence occurs:

- 4 - Recent debris
- 3 - Gritty marl
- 2 - Pale yellow marly limestone containing foraminifera
- 1 - Gritty marl (bottom not seen)

The lower part, which was under water, could not be examined. The foraminifera collected in this section belong to the following genera: *Textularia*, *Clavulina*, *Quinqueloculina*, *Spiroloculina*, *Triloculina*, *Austrotrilina*, *Nonion*, *Elphidium*, *Reussella*, *Taberina*, *Discorbis*, *Valvulineria*, *Rotalia*, *Eponides*, *Asterigerina*,

*Anomalina*, *Cibicides*, *Gypsina*, *Nephrolepidina*, *Trybiliolepidina*, *Miogypsina* s.s., and *Lepidosemicyclina*. This fauna is similar to that of the "*Orbiculina*" limestone noted earlier, and the beds are designated the **Bhogat beds**. This is probably the section mentioned by Fedden as containing the foraminiferan "*Conulites*" (which is actually *Lepidocyclus*). This fossil was mistaken by earlier workers for *Nummulites*, and gave rise to the belief that Eocene beds occur in Kathiawar.

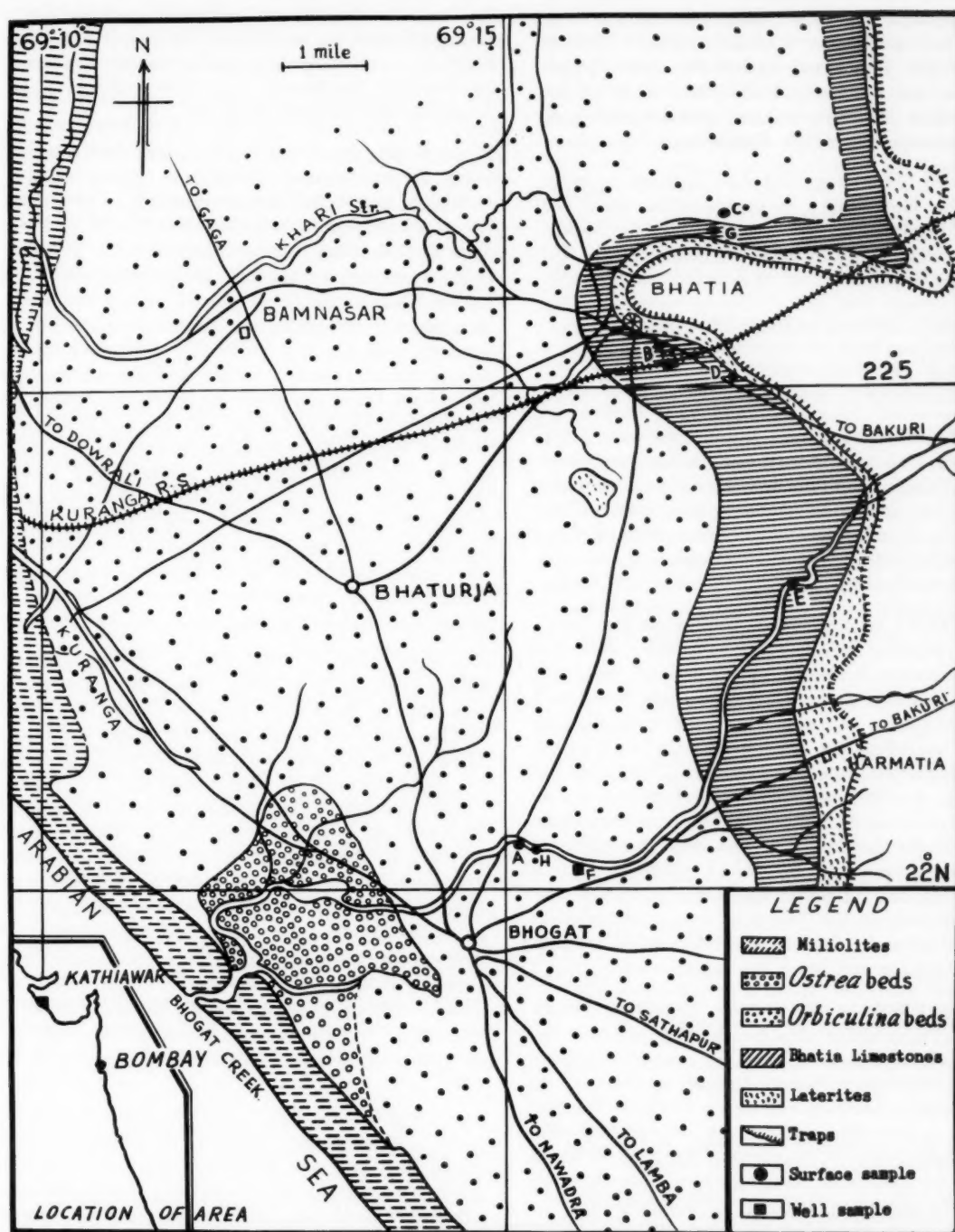
As already indicated, the beds below the foraminiferal limestone and marl could not be investigated, as they were under water; but in a newly dug well, about one-half mile east of the locality mentioned above, a more complete section was observed. The Bhogat beds described above are underlain by much darker limestones, similar to the Bhatia limestone. The following foraminifera were noted: *Clavulina*, *Quinqueloculina*, *Spiroloculina*, *Triloculina*, *Elphidium*, *Rotalia*, *Cibicides*, and *Miogypsina* s.s. The fauna is similar to that of the Bhatia limestone.

Downstream, toward the seacoast, younger and younger rocks are found. Beds containing *Ostrea* are followed farther downstream by the Dwarka beds, which are overlain by the miliolites (Porbander limestone and sub-Recent formations).

#### AGE OF THE FAUNA

The earliest references to the type section along the Gaj River in Sind are those of Blanford (1876, 1880). He described this section and regarded the Gaj series as Miocene, possibly Upper Miocene, in age. This view was supported by Duncan and Sladen (1882), who examined the Miocene faunas of Kathiawar and Kutch and compared them with the Gaj fauna of Sind.

# MIocene OF WESTERN INDIA



TEXT-FIGURE 3

GEOLOGIC MAP OF BHATIA-BHOगत AREA (KATHIAWAR)



In 1853, Carter described *Taberina malabarica* (Carter), under the name *Orbitolites malabarica* Carter, from the Quilon limestones, to which he assigned a Pliocene age. In 1861, Carter redescribed the same species under the name *Orbiculina malabarica* (Carter), from a pale yellow limestone exposed near Porbander, to which he assigned a middle Tertiary age.

Vredenburg (1906) regarded the Gaj series as upper Aquitanian; later (1921), he correlated the upper Gaj with the Burdigalian. Vredenburg (1921) and Martin (1931), using molluscan evidence, correlated the Gaj beds as follows:

Burdigalian: Upper Gaj (Pyalo beds of Burma;  
Njadlindung beds of Indonesia);  
Aquitanian: Lower Gaj (Kama beds of Burma;  
Rembang beds of Indonesia).

Wayland and Davies (1923), who examined the Jaffna limestones of Ceylon, which contain *Taberina malabarica* (Carter), considered these beds to be upper Vindobonian in age. Kumar and Pichamuthu (1933) studied the fauna of the Quilon beds, correlating them with the Gaj of Sind, and pointed out that the fauna is a mixture of forms characteristic of Sind and Burma.

Cotter (1938), who recorded *Alveolinella* and *Spiroclypeus*, together with *Taberina malabarica*, from the Jaffna limestone in Ceylon, also considered the fauna to be of probable upper Vindobonian age. Furon and Lemoine (1938, p. 1425) expressed the following opinion regarding the Ceylon and Quilon Miocene beds (translated from the French): "These are the remnants of a Vindobonian, to be more precise a Tortonian, transgression. English authors date these beds with hesitation because of the uncertain stratigraphic position of *Ostrea vireleti*, which signifies either a Burdigalian or a Tortonian age. Actually, *Ostrea vireleti* exists only in the Tortonian, and is preceded in the Burdigalian by *Ostrea preavereleti*, which is much more triangular and much less ornamented."

Glaessner (1943, p. 60) stated: "Definite evidence, however, is available only for the correlation of the base of the Burdigalian with the base of the Rembangian, the rest being conjectural as long as no further palaeontological evidence is found. In the light of new stratigraphic and micropalaeontological data earlier inter-regional correlations based on mollusca cannot be considered as satisfactory." He gave the following correlation based on foraminifera:

Burdigalian: Upper Gaj and Kyankkoh of Burma.  $f_1$ - $f_2$   
Aquitanian: Lower Gaj and Kema of Burma.....  
.....upper part of  $e$

Henson (1948, 1950) considered the fauna of the Fars series of the Persian Gulf, which contains *Taberina malabarica*, to be Middle Miocene in age. This fossil also occurs in Syria in Middle Miocene limestone, together with *Borelis melo* var. *curdica* (Reichel) and *Meandropsina anahensis* Henson.

Eames (1950), after a detailed review of the molluscan fauna of the Miocene of Ceylon, Quilon, Karikal, Cuddalore and Kathiawar, concluded that no Middle Miocene beds exist in India. He stated (1950, p. 236): "The Quilon fauna has been regarded as of Vindobonian age, not on account of any similarity with known Vindobonian faunas elsewhere, but arbitrarily on account of the presence of *Archaias malabaricus* in quantity at Quilon and Ceylon. . . . The most significant evidence, however, is that *Archaias malabaricus* was found fairly commonly in collections made, by geologists of the Burmah Oil Co., Ltd., from the Gaj series of the Gaj River section, which is the type area for the Gaj series. Taking the evidence as a whole, these Ceylon, Quilon, and Kathiawar faunas all seem to be of the same age (probably upper Gaj, i.e., upper part of the Lower Miocene), and the beds in which they were found were probably all formed during the same Lower Miocene transgression as were the marine Gaj deposits of Sind and Cutch."

Glaessner (1951, p. 281) discusses the age of Australian Miocene beds. With regard to *Austrotrillina howchini*, he says: "This fossil is widely distributed but has not been found anywhere above the Lower Miocene. There seems to be no reason at all to assume a younger age for these beds containing it. . . ." Mohler (1949) considered the uppermost portion of stage  $e$  (substage  $e_s$ ) to be lower Burdigalian because of the presence of *Flosculinella reicheli* Mohler. This view was accepted by van Bemmelen (1949). However, Glaessner (1953) discarded the idea of correlating the lower Burdigalian with stage  $e_s$ , as suggested by Mohler. He considered that the lowest recognizable division of stage  $f$  is probably Burdigalian. Drooger (1954) stated: "In older Burdigalian, the *Miogypsina* sequence continues with *M. (Miogypsina) irregularis* followed by *M. (Miogypsina) intermedia* in the younger parts."

Jacob and Sastri (1952) investigated Quilon material from a borehole near Chavara (lat.  $26^{\circ}32'$  N., long.  $80^{\circ}58'$  E.), near Quilon, and reported the following fossil assemblage: *Lepidocyclina* (*Nephrolepidina*) *chavarana* Jacob and Sastri, *Lepidocyclina* (*Nephrolepidina*) *sumatrensis*, *Lepidocyclina* (*Nephrolepidina*) cf. *marginata* (Michelotti), *Austrotrillina howchini* (Schlumberger), and *Archaias malabaricus* (Carter).

On the basis of *Nephrolepidina* and *Austrotrillina howchini*, they correlated these beds with the Burdigalian of the Surat-Broach area and with Glaessner's stage  $f_1$ - $f_2$  of the Indo-Pacific.

With regard to *Lepidocyclina* (*Nephrolepidina*) *chavarana* Jacob and Sastri, the description and figure (Jacob and Sastri, 1952, p. 195, pl. 16, fig. 12b), particularly the embryonic apparatus and the stellate character of the test, suggest that it is a *Trybliolepidina*. This subgenus has been reported, as noted above, from Kathiawar, along with *Taberina malabarica* (Carter), from beds that are regarded as upper Burdigalian.

# CONCLUSIONS

After mapping the area, and from a detailed study of the foraminiferal assemblage, we have come to the conclusion that no Middle Miocene beds are present, as previously reported. *Lepidosemicyclina* Rutten, 1911, which was suppressed, has been reinstated as a subgenus of *Miogypsina* Sacco by Mohan (1955). The beds now recognized are recorded here in descending order:

- 3 - "Orbiculina" limestones; marly limestones of Bhogat and Verawal, containing *Austrotrillina howchini* (Schlumberger), *Taberina malabarica* (Carter), *Lepidocyclina* (*Nephrolepidina*) *borneensis* (Provale), *Lepidocyclina* (*Nephrolepidina*) *martini* (Schlumberger) var. nov., *Lepidocyclina* (*Nephrolepidina*) *morgani* (Lemoine and Douvillé), *Lepidocyclina* (*Trybliolepidina*) spp. nov., *Miogypsina* (*Miogypsina*) *irregularis* (Michelotti), *Miogypsina* sp. nov., and *Miogypsina* (*Lepidosemicyclina*) *polymorpha* (Rutten).
- 2 - Visawara limestone; yellow to dark yellow compact limestones containing *Austrotrillina howchini* (Schlumberger), *Lepidocyclina* (*Nephrolepidina*) *borneensis* (Provale), *Miogypsina* (*Miogypsina*) *irregularis* (Michelotti) and *Miogypsina* (*Lepidosemicyclina*) *thecidaeformis* Rutten; agate conglomerates of Bhavnagar, containing *Miogypsina* cf. *antillea*.
- 1 - Bhatia limestone (*Miogypsina* beds); dark yellow to brown, hard, compact, lateritic limestone containing *Miogypsina* (*Miogypsina*) *irregularis* (Michelotti) and *Miogypsina* (*Miogypsina*) sp. nov.

Unit 3 is upper Burdigalian; units 2 and 1 are lower Burdigalian. These correspond to stage  $f_1$ - $f_2$  of the letter classification of Indonesia.

Unit 2 (Visawara limestone) differs from unit 3 ("Orbiculina" limestone) both in lithology and in faunal content. *Taberina malabarica* and *Trybliolepidina* are absent from these beds, and the fauna is definitely older. In field sections, it was found underlying unit 3. Unit 2 is correlated with the agate conglomerates of eastern Kathiawar, near Gogha, and of the Surat-Broach region, which are lower Burdigalian.

Unit 1 (Bhatia limestone) is regarded as the oldest Miocene horizon recognized in Kathiawar, and it is provisionally referred to the lower Burdigalian. The *Miogypsina* occurring in this bed appears to be a morphologically older species than those of unit 2.

No Middle Miocene horizon appears to be present in western India. The "Orbiculina"-bearing beds, hitherto considered to be Middle Miocene, are considered to be upper Burdigalian. The lower Burdigalian beds found are characterized by the presence of *Nephrolepidina* and by the absence of *Trybliolepidina* and *Eulepidina*. *Austrotrillina howchini*, an important Indo-Pacific species, is found in the Burdigalian of western India and is accompanied by *Lepidosemicyclina*. The presence of *Trybliolepidina* and *Austrotrillina howchini* emphasizes the faunal affinities between Kathiawar and the Indo-Pacific region.

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**ABSTRACT:** *Radiolaria* recently found in shale of the Franciscan group (Jurassic and Cretaceous) in California are somewhat better preserved than those previously found in cherts of this group. Seven forms are described, figured, and identified generically.

## **Radiolaria from the Franciscan group, Belmont, California**

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### **INTRODUCTION**

Radiolaria were found in shale of the Franciscan group exposed in 1951 during excavation for industrial construction east of Belmont, California. Before excavation started, the site was a low hill of bedrock about 60 acres in area, that rose about 100 feet above the alluvium and tidal marsh deposits on the west shore of San Francisco Bay approximately 15 miles southeast of San Francisco, in the N½ NE¼ sec. 11, T. 5 S., R. 4 W. Lawson (1914) indicated on the geologic map of the San Mateo quadrangle (15-minute series) that the bedrock of which the radiolarian shale is a part is the Sausalito chert of the Franciscan group.

The Radiolaria were found in the shale 1150 feet southeast of Belmont Creek and about 1000 feet southwest of Bayshore freeway. The shale is in beds 4 inches to 2 feet thick and is interbedded with greywacke, radiolarian chert, and highly altered greenstone, all dipping northeast between 15° and 20°. The shale is moderate red to dark yellowish brown; some of it is laminated, consisting of alternating thin laminae of dark yellowish-brown and grayish-orange color. The Radiolaria are easily seen with the hand lens as rounded pellets. A prominent fault located 100 feet southwest of the radiolarian shale cuts northwesterly across the area and dips 40° to 50° northeast. Bedrock southwest of the fault is exposed over about 30 acres and is an olive gray, well-cemented conglomerate of well-rounded pebbles 1½ inches in average size, with a maximum size of 13 inches, in a matrix of coarse-grained sandstone. The dip of the conglomerate is northeast. Lawson (1914) designated this conglomerate "probably Knoxville formation" on the geologic map of the San Mateo quadrangle.

The Radiolaria of this shale of the Franciscan group can be isolated from the matrix by soaking the rock first in gasoline and then in water, and subsequently sieving. Their identification is hindered by their relatively poor state of preservation. No delicate tests, nor even the spines of the more robust forms, have been preserved, and those that are present are filled with iron-stained silica, which obscures internal details. Further difficulties have been introduced by lateral compression of the tests, which occurred during the compaction of the shale. Conical forms lying flat on a microscope slide therefore appear flared at a wider angle than they must originally have had, and it is difficult to distinguish between originally spherical, ellipsoidal, and discoidal skeletons. More of their structure can be determined, however, than in those few forms figured and generically determined by Hinde (1894) from chert of the Franciscan group.

Apart from Hinde's record, the only description of Radiolaria of Mesozoic age from California is that of Campbell and Clark (1944), who described a well-preserved assemblage from a small limestone sample which is probably of the same age as the Moreno shale. There is little similarity between the assemblage from the shale of the Franciscan group and that described by Campbell and Clark.

Accurate dating of the assemblage in the shale of the Franciscan group is impossible at present because of the relatively poor state of preservation and the small number of descriptions of faunas of Mesozoic age with which it might be compared. In the following discussion of forms present in the shale, it will be observed that there are similarities with some species recorded



from the Jurassic, and with others from the Cretaceous, of other parts of the world. The Radiolaria therefore at present throw no light on the question of whether this shale is Jurassic or Cretaceous in age.

Figured specimens will be deposited in the collections of the United States National Museum, Washington, D. C.

#### SYSTEMATIC DESCRIPTIONS

### Class RADIOLARIA

### Order SPUMELLARIA

### Suborder Sphaerellaria

Tests belonging to this group are abundant in the assemblage, but the impossibility of determining details, such as the number of concentric shells and the nature of the spines, prevents identification of most of them. None with spongy skeletons was found, probably because of their having been dissolved or otherwise obliterated. One form can be tentatively identified generically.

### Genus *Conosphaera* Haeckel, 1862

#### Text-figure 1

Tests belonging to this genus are rather common in the assemblage. They are spherical, thick-walled, bearing low conical to hemispherical elevations, and the entire surface has small subcircular pores. Diameter 140-210 $\mu$ .

Tan Sin Hok (1927, p. 36, pl. 6, fig. 10) has described a similar large species, *Conosphaera tuberosa*, from sedimentary rocks of Mesozoic age on Rotti Island, near Timor. Parona (1890, pp. 148-149, pl. 1, figs. 9-10) described two rather similar species, *Conosphaera fossilis* and *Conosphaera antiqua*, from the Jurassic near Laveno in northern Italy. *Conosphaera mammillata* Hinde (1908, pp. 718-719, pl. 5, fig. 10), described from Triassic(?) rocks of Rotti Island and East Ceram, East Indies, and *Conosphaera sphaeroconus* Rüst (1898, pp. 13-14, pl. 4, fig. 8), from the Jurassic near Laveno and the Neocomian near St. Cassian, northern Italy, appear to differ from the form from the Franciscan group in their more regular arrangement of protuberances and pores. *Conosphaera sphaeroconus* has also been recorded, though somewhat doubtfully, by Heitzer (1930, p. 386, pl. 27, fig. 4) from the middle Jurassic of the Sonnwend Mountains, in the Austrian Tyrol.

### Order NASSELLARIA

### Suborder Cyrtellaria

Members of this group, and particularly forms belonging to the genus *Dictyomitra*, are common in the assemblage, but the difficulty of distinguishing segmental divisions and the probable loss of spines hinders even generic identifications.

Only those forms that are most common, or of which the characters can be determined with some certainty, are discussed below.

### Genus *Cryptocephalus* Haeckel, 1882(?)

#### Text-figure 2

A few specimens of distinctive form are assigned doubtfully to this genus (in the emended sense of Campbell, 1954), although the apical portion is indistinct or broken off in every specimen found. The cephalis appears to be small, spherical; there is no collar stricture. The thorax is narrow apically, rapidly broadening to become campanulate. Approximately sixteen to twenty longitudinal ribs extend along the thoracic wall, separating small circular pores in longitudinal rows. The mouth is somewhat constricted by a peristomial ring. Total length 160-190 $\mu$ , breadth 125-145 $\mu$ .

This form seems to resemble closely *Sethamphora pulchra* Squinabol (1904, pp. 213-214, pl. 5, fig. 8) from the Cretaceous of Euganei, in northern Italy. *S. squinaboli* Hinde (1908, p. 723, pl. 6, fig. 6), described from Triassic(?) rocks on Rotti Island, near Timor, differs from the form from the Franciscan group in its smaller size and fewer longitudinal ribs.

### Genus *Dicolocapsa* Haeckel, 1882

#### Text-figure 3

Common tests apparently belonging to this genus possess a large subspherical thorax (breadth 175-235 $\mu$ ) surmounted by a small hemispherical cephalis, which projects only 10-15 $\mu$ . Thoracic pores are subcircular, usually rather regularly hexagonally arranged; there are thirteen to seventeen on a half circumference. No mouth was found on examples that could be examined from the base. This is probably the form that Hinde placed in the genus *Sethocapsa*, although neither his description nor his figure indicates the presence of an apical horn.

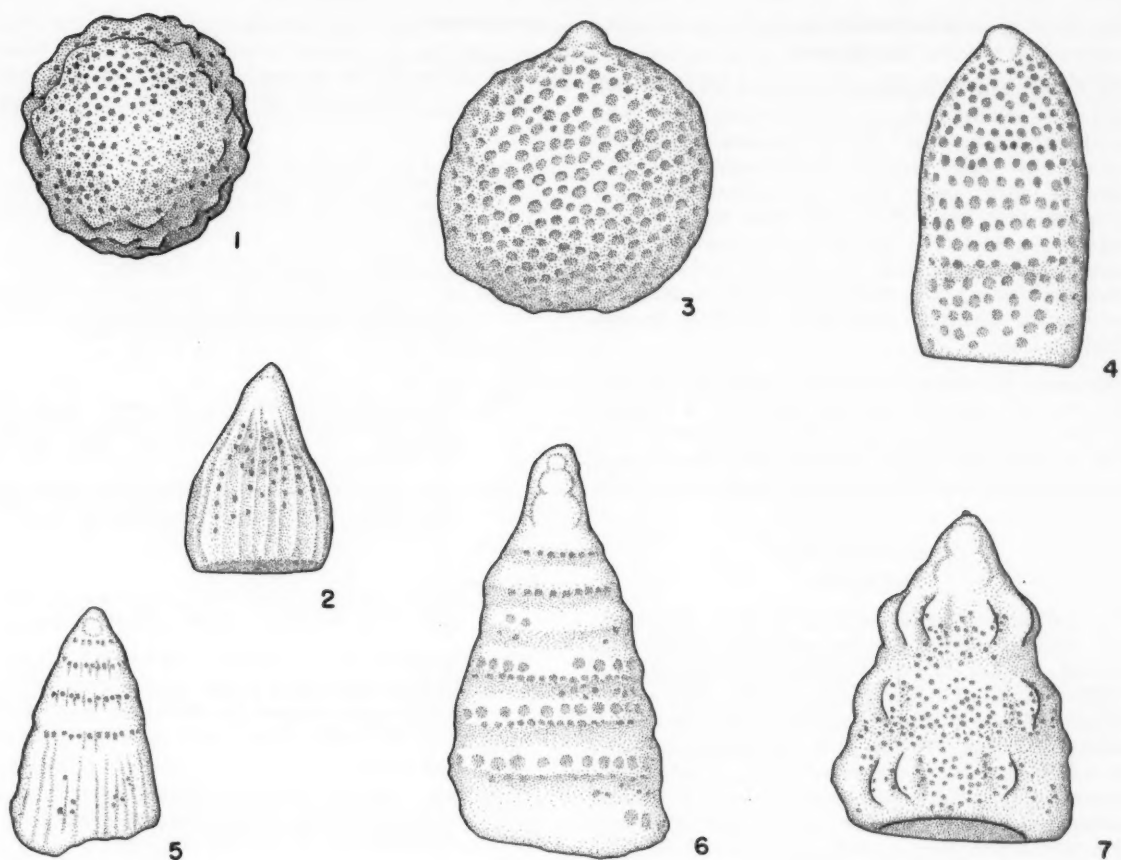
This form is very similar to *Dicolocapsa microcephala* Heitzer (1930, pp. 394-395, pl. 28, figs. 43a-b), described from the middle Jurassic of the Sonnwend Mountains, in the Austrian Tyrol. *Dicolocapsa kalilimnii* Vinassa (1901, p. 506, pl. 1, fig. 36), described from the Cretaceous of Karpachos Island, near Crete, somewhat resembles the form from the Franciscan group, but appears to have fewer thoracic pores. *Dicolocapsa cephalocrypta* Tan Sin Hok (1927, p. 44, pl. 8, fig. 42), from rocks of Mesozoic age on Rotti Island, near Timor, is similar, but apparently the cephalis is enclosed to a greater extent by the thorax.

### Genus *Tricolocampe* Haeckel, 1882

#### Text-figure 4

Individuals belonging to this genus are not common in the assemblage, but six specimens examined showed the following characters: Entire test thick-walled and generally

# FRANCISCAN RADIOLARIA OF CALIFORNIA



TEXT-FIGURES 1-7

1, *Conosphaera* sp.; 2, *Cryptocephalus*? sp.; 3, *Dicolocapsa* sp.; 4, *Tricolocampa* sp.; 5, *Dictyomitra* sp. a; 6, *Dictyomitra* sp. b; 7, *Dictyomitra* sp. c. All from shale of the Franciscan group; Belmont, California. All  $\times 200$ .

cylindro-conical. Cephalis small, spherical, almost completely enclosed in the long cylindro-conical thorax. Abdomen short; no lumbar stricture. Thoracic and abdominal pores similar, subcircular, arranged hexagonally with usually pronounced transverse alignment. The thorax has eleven to seventeen transverse rows of pores; at the base of the segment there are approximately twelve to fourteen pores on a half circumference. Total length 170-300 $\mu$ , breadth 105-185 $\mu$ . There are no described species closely resembling this form.

## Genus *Dictyomitra* Zittel, 1876

Specimens belonging to this genus are common in the assemblage, and sufficient structural details are preserved to make possible the tentative separation of three species.

## *Dictyomitra* sp. a

### Text-figure 5

Test rather narrowly conical, with smooth outline only occasionally modified by slight segmental bulges. Cephalis spherical; no collar stricture. The next four or five segments successively increasing somewhat in length, marked off by transverse rows of small subcircular pores; there are ten to fifteen pores on a half circumference. Longitudinal ribs usually present between pores of the transverse rows, but these are not continuous across the proximal segments. Beyond these four or five transverse rows of pores, no further segmental divisions can be distinguished. The longitudinal ribs become continuous and more pronounced, and in a few individuals the ribs separate pores that are approximately rectangularly arranged. Total length 145-285 $\mu$ , breadth 75-140 $\mu$ . There are no described species closely resembling this form.

**Dictyomitra sp. b**

Text-figure 6

Test conical, with all segments except the first two or three marked by annular swellings. Cephalis subspherical, with no stricture between it and the small poreless thorax. Third segment also usually poreless. The following two to four segments usually have a single row of small subcircular pores near their bases. Then follow three to five narrow segments, each with a row of large subcircular pores medially and a row of small pores distally. In a few specimens, small pores can be distinguished in the constrictions between the segments. Total length 255-330 $\mu$ , breadth 155-185 $\mu$ .

*Dictyomitra hornatissima* Squinabol (1904, pp. 230-231, pl. 9, fig. 12), described from the Cretaceous of Euganei, in northern Italy, appears to be very similar to this form from the Franciscan group, although some details cannot be compared because of the poor preservation of the latter.

**Dictyomitra sp. c**

Text-figure 7

Test conical, with outline modified by three or four annular series of rounded protuberances that probably correspond to individual distal segments. Small subspherical cephalis and ovate thorax enclosed in the thick-walled, conical shell apex. The first row of protuberances, immediately following the thorax, is very pronounced, and the subsequent, almost equidistant series are usually less prominent. Pores small, subcircular, in some individuals restricted to the zones between rows of protuberances, in others visible also on the protuberances themselves. Total length 250-300 $\mu$ , breadth 180-190 $\mu$ .

No described species closely resembles this form. *Dictyomitra elegans* Squinabol (1904, pp. 232-233, pl. 10, fig. 5), described from the Cretaceous of Euganei, northern Italy, shows some similarities with the form from the Franciscan group, but segments subsequent to the third lack protuberances, and pores are present on the cephalis and thorax.

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**ABSTRACT:** Three pelagic species of foraminifera have been studied along a line parallel to the coasts of North and South America. Variations in abundance and size are noted in relation to latitude, depth, salinity, temperature and circulating currents. Miocene samples from Buff Bay, Jamaica, have been used in an attempt to relate the ecology of that time with the findings of this study.

## Some ecologic data relating to pelagic foraminifera

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### INTRODUCTION

The late Dr. Joseph A. Cushman was interested in the factors determining the size variations displayed by the foraminifera. A study conducted by Cushman and Harris (1927) on *Globorotalia menardii* (d'Orbigny) indicated a decrease in size in that species both northward and southward from the Caribbean area. Only five samples were analysed, so that detailed conclusions were lacking. A similar study was also conducted by Cushman and Todd (1941) concerning size variations in the genus *Bolivina*. A similar decrease in size was noted in the northern waters.

This paper presents the findings of a study on the size variations of three pelagic species of foraminifera along a line parallel to the coasts of North and South America, and discusses certain ecologic factors that might account for the differences noted.

The samples studied were from the Albatross collections taken in the Atlantic from 1883 to 1887. A representative group of samples was obtained from latitudes 42°47' N. to 24°17' S. Pelagic species were chosen from the samples for this study because they would be least affected by variations in the bathymetric zones and relative distances from the coasts.

The thirty-seven samples studied are numbered from north to south and are shown on the index map (text-fig. 1). Table 1 lists the corresponding Albatross stations, latitudes, longitudes, surface temperatures, abundance, and size determinations obtained in this study.

Whenever possible, 100 specimens of each species were picked from the sample; if less than 100 were present, all were mounted for study. Approximately half the samples had been previously picked by Dr. Cushman and Ruth Todd for a similar study contemplated at some time; this aided greatly in the time-consuming job of sorting through the material. Abundance of the specimens, as indicated in Table 1, is based on the following system: R (rare) = less than 15; F (frequent) = 15-30; C (common) = 30-45; A (abundant) = more than 45.

After measurement of the specimens, graphs were made for the study of the relationships of size and abundance to various ecologic factors.

### SPECIES STUDIED

The species selected for study are *Orbulina universa* d'Orbigny, *Globigerinoides sacculifera* (Brady), and *Globigerinoides rubra* (d'Orbigny).

*Orbulina universa* d'Orbigny: This species, as described by Cushman (1924), has the "test in its early development consisting of a series of *Globigerina*-like chambers, the adult developing a globular chamber about this early *Globigerina*-like portion; surface usually finely reticulate, with a small pit at the bottom of each reticulation and one larger circular aperture forming the main opening into the interior; in the living condition the surface develops long spines from the exterior."



Only one measurement was necessary on this species, as most forms are spherical. The largest diameter measured was 1.16 mm., in sample 35 (Albatross D2760). From the graphs in text-figure 2, the average diameter can be placed at approximately 0.7 mm.

*Globigerinoides sacculifera* (Brady): Cushman (1924) describes this species as having the "test composed of numerous chambers, the earlier ones similar to *Globigerina bulloides*, but very soon developing accessory openings, especially on the dorsal side of the test where the new chamber meets the previous one; early chambers nearly spherical, the later ones becoming somewhat elongate and compressed, the final chamber in fully developed or senescent specimens often flattened and the outer end with numerous projecting points; wall strongly reticulate, except in the final chamber, which is often smoother than the preceding ones; aperture large, on the ventral side near the umbilicus, with numerous other secondary openings about the inner border of the chamber."

Length measurements of this form were taken from the end of the enlarged, compressed final chamber to the point at the greatest distance from it. The greatest length observed in this species was 1.36 mm., from sample 33 (Albatross D2756). The graphs in text-figure 2 indicate that the average length for this species is approximately 0.8 mm. Widths on all specimens were measured at right angles to the lengths, in order to determine ratios. However, the ratios exhibited by this species did not show any pertinent change as in an earlier study on *Bolivina* by Cushman and Todd (1941). On the average, the ratio of width to length was 1:1.4.

*Globigerinoides rubra* (d'Orbigny): Cushman (1924) gives the following as a description of this species: "Test composed of several inflated chambers arranged in an elongate trochoid spire of about three volutions, each with three chambers; wall reticulate, with spines in pelagic specimens; aperture an arched opening at the umbilical border of the chamber, and in the later chambers this is supplemented by two or more nearly circular openings on the upper border of the chamber near its connection with the preceding chambers; color of the early chambers, sometimes all the chambers, pink."

The color of *Globigerinoides rubra* was well developed in the samples studied. Even in sample 5 (Albatross D2043), taken at latitude 39°49' N., the species was abundant, with the pinkish color that is well developed in the West Indies region.

The form of this species made measurements somewhat more difficult than in the preceding groups. Specimens of *Globigerinoides rubra* were mounted so that the elongate trochoid spire was perpendicular to the slide. Length measurements were then taken bisecting the arched aperture. Measurements of the width were taken at right angles, across the two gibbous pinkish early chambers. The longest measurement was 0.76 mm., from sample 35 (Albatross D2760). From text-figure 2, the average length of the species can be approximated at 0.55 mm. Ratio of width to length averages approximately 1:1.2.

All these forms exhibit a spherical or gibbous test that is well adapted to pelagic life. Not much is known as to the living habits of these micro-organisms, nor of the depths of the seas at which they flourish when alive. However, it is fairly well established that they are pelagic and thus should be treated as part of the plankton of the seas. The surface conditions and circulation of the sea water are more closely associated ecologic factors than the benthonic environments discussed by some previous workers. The areal distribution of these forms is also dependent on the surface movements of the water and not on the activities of the individual organism, as in the vagrant type. How long the tests remain afloat after death is uncertain, so that in studying the organic remains brought up by the dredge, one must assume that they represent individuals who have lived above this spot or close to it, and have sunk to the bottom after death.

#### RELATION OF SIZE TO LATITUDE

In the studies mentioned previously, the sizes of the foraminifera were found to decrease northward and southward from the Caribbean area. Those investigations were somewhat limited in the number of samples studied, so that no graphs were presented to show this size variation in relation to latitude. The present work has touched only the eastern parts of the Caribbean, in an attempt to obtain samples parallel to the coasts as shown in text-figure 1.

It is observed in the plots of size against latitude in text-figure 2 that the maximum size of the tests is attained in the vicinity of the Lesser Antilles, between latitudes 15° and 20° N. In the case of *Orbulina universa* and *Globigerinoides sacculifera*, this maximum is reduced to the north, to about latitude 40° N., where minimum sizes occur or the species is absent. In the case of *Globigerinoides rubra*, the maximum of the Lesser Antilles region drops off slightly in the vicinity of latitude 30° N., but returns to another high at about latitude 38° N. before it drops off in a manner similar to the other two species.

## ECOLOGY OF PELAGIC FORAMINIFERA

TABLE 1

Sample no.	Albatross Sta. no.	Latitude	Longitude	Surface temp. (°F.)	Depth (fathoms)	<i>Orbulina universa</i>		<i>Globigerinoides sacculifera</i>			<i>Globigerinoides rubra</i>		
						Diam. (mm.)	Abundance	Length (mm.)	Width (mm.)	Abundance	Length (mm.)	Width (mm.)	Abundance
		North	West										
1	D2705	42°47'00"	61°04'00"	67°	1255	—	—	0.58	0.44	R	—	—	—
2	D2063	42°23'00"	66°23'00"	57.5	141	0.25	R	—	—	—	0.36	0.30	R
3	D2706	41°28'30"	65°35'30"	66°	1188	0.62	R	0.77	0.57	R	0.47	0.37	R
4	D2535	40°03'30"	67°27'15"	70	1149	0.43	R	—	—	—	0.42	0.33	R
5	D2043	39°49'00"	68°28'30"	72	1467	0.64	A	0.77	0.59	F	0.54	0.45	A
6	D2050	39°42'50"	69°21'20"	72	1050	0.64	A	0.76	0.60	R	—	—	—
7	D2052	39°40'05"	69°21'25"	73	1089	0.59	A	0.77	0.53	R	0.54	0.46	F
8	D2042	39°33'00"	68°26'45"	71	1555	0.66	A	0.83	0.63	R	0.56	0.48	R
9	D2563	39°18'30"	71°23'30"	77	1422	0.61	F	0.80	0.60	R	0.57	0.47	R
10	D2038	38°30'30"	69°08'25"	76.5	2033	0.64	A	0.83	0.60	R	0.59	0.49	R
11	D2039	38°19'26"	68°20'20"	81	2369	0.59	A	0.75	0.59	R	0.57	0.49	R
12	D2097	37°56'20"	70°57'30"	72.5	1917	0.58	A	0.80	0.58	F	0.57	0.48	R
13	D2105	37°50'00"	73°03'50"	63	1395	0.63	A	0.72	0.53	R	0.56	0.47	R
14	D2108	37°12'22"	74°20'04"	54	788	0.64	A	—	—	—	0.59	0.48	R
15	D2226	37°00'00"	71°54'00"	80	2045	0.66	A	0.82	0.56	F	0.55	0.45	R
16	D2224	36°16'30"	69°21'00"	79	2574	0.66	A	0.79	0.59	A	0.60	0.50	R
17	D2225	36°05'30"	69°51'45"	78	2512	0.63	A	0.81	0.61	F	—	—	—
18	D2111	35°09'50"	74°57'40"	76	938	0.69	A	0.89	0.59	F	0.55	0.46	C
19	D2614	34°09'00"	76°02'00"	78	168	0.60	A	0.75	0.56	C	0.55	0.47	A
20	D2677	32°39'00"	76°50'30"	78	478	0.73	A	0.87	0.62	A	0.56	0.47	A
21	D2668	30°58'30"	79°38'30"	76	294	0.65	A	0.74	0.60	A	0.49	0.40	A
22	H875	28°42'45"	76°39'00"	70	762	0.67	A	0.74	0.52	R	0.42	0.35	A
23	D2660	28°40'00"	78°46'00"	74	504	0.74	A	0.83	0.61	A	0.50	0.42	C
24	D2641	25°11'30"	80°10'00"	74	60	0.70	A	0.79	0.55	C	0.55	0.46	A
25	D2629	23°48'40"	75°10'40"	73	1169	0.67	C	0.70	0.56	R	0.44	0.37	A
26	H57	17°49'06"	65°29'00"	78°	2188	0.81	A	0.90	0.67	A	0.57	0.49	A
27	D2751	16°54'00"	63°12'00"	81	687	0.77	A	0.88	0.54	A	0.56	0.49	A
28	H65	16°42'02"	65°02'20"	78°	2312	0.81	A	0.92	0.68	A	0.59	0.49	A
29	D2117	15°24'40"	63°31'30"	78	683	0.66	A	0.80	0.64	A	0.54	0.47	A
30	H80	13°56'35"	63°02'00"	80°	684	0.73	A	0.90	0.66	A	0.53	0.44	A
31	H89	12°07'30"	62°24'00"	80°	1552	0.69	C	0.82	0.63	F	0.50	0.42	A
32	H1095	01°53'00"	43°00'00"	80	2449	0.72	A	0.83	0.61	F	0.48	0.39	A
		South	West										
33	D2756	03°22'00"	37°49'00"	79	417	0.62	A	0.83	0.61	A	0.44	0.37	C
34	D2758	06°59'30"	34°47'00"	79	20	0.64	R	0.82	0.62	R	0.48	0.41	C
35	D2760	12°07'00"	37°17'00"	80	1019	0.82	A	0.86	0.63	A	0.62	0.54	F
36	D2761	15°39'00"	38°32'54"	79	818	0.75	F	0.84	0.63	R	0.51	0.41	F
37	D2763	24°17'00"	42°48'30"	75	671	0.75	A	0.84	0.64	F	0.58	0.51	A

R (rare) = less than 15; F (frequent) = 15 - 30; C (common) = 30 - 45; A (abundant) = more than 45.

\* (From U. S. Hydrographic Chart no. Misc. 10688.)

South of the Lesser Antilles, all three species show similar curves. A size reduction is noted in the vicinity of the Equator, followed by a rise to a maximum at about latitude 13° S. From this point south to the limit of the samples the curve drops off slightly.

#### RELATION OF ABUNDANCE TO LATITUDE

When the number of specimens in each sample is plotted against the latitude, two localities are observed where all three species are abundant. These are between latitudes 13° and 20° N., and latitudes 30° and 34° N. As a general rule, *Orbulina universa* is found in abundance throughout the area studied, whereas abundant occurrences of the other two species are limited more to the tropical waters. This fact may also be related to the generally spherical shape of *Orbulina universa*, which would permit a much wider distribution.

#### FACTORS AFFECTING SIZE AND ABUNDANCE

The ecologic factors that have a bearing on variations in abundance and size in these pelagic foraminifera are all interrelated. For example, the temperature affects the percentages of salinity, the abundance of food, the circulation of the water, and other factors. Temperature itself is affected by depth, relation to land masses, circulation, and other factors. In the following discussions of depth, temperature, salinity, and circulation, it must be remembered that the effects of these are all dependent on one another to some extent.

#### Depth

Bathymetric zones have been established on the abundance of various types of foraminifera present in samples, and the Globigerinidae are often cited as indicators of great depths. But since they are pelagic and at the mercy of the movements of the oceans, great numbers may be washed into shallower waters during storms or even swept onto the beaches to become a conspicuous part of the littoral. Thus the organic remains of this family should be used with care when applied as a criterion for great depths. It would be safer to assume that their presence indicates open-sea conditions in which no barriers prevented their dispersal.

When size and abundance are plotted against depth in the samples studied, no definite conclusions can be drawn regarding this relationship. The species studied

are found in abundance from 60 fathoms to over 2500 fathoms. Even at 20 fathoms, although the species are rare, the sizes are about average.

One point to consider in the depth-abundance relationship is the place of accumulation on the sea floor. A greater number of tests will be deposited in the depressions of the sea floor than along the adjacent topographic highs. Thus, if the dredge should scrape along a high between depressions, there might well be a paucity of material, although there might have been an abundance a few feet away.

Depth, associated with pressure and temperature, also affects the solubility of the tests of these pelagic organisms. With an increase in depth there is an increase in the solubility of the calcium carbonate tests. This factor may also play a role in the abundance of their remains at depth.

#### Temperature

In plotting size and abundance against temperature, the surface conditions were used because they are more closely associated with the living environments of the organisms than the temperatures of the bottoms from which the organic remains were dredged. The surface temperatures presented in Table 1 are taken from the records of the Albatross, except those marked with an asterisk, which were taken from United States Hydrographic Chart no. Misc. 10688.

*Orbulina universa* shows no direct relationship with the surface temperatures. It is abundant and of average size at temperatures of 54° F. and above.

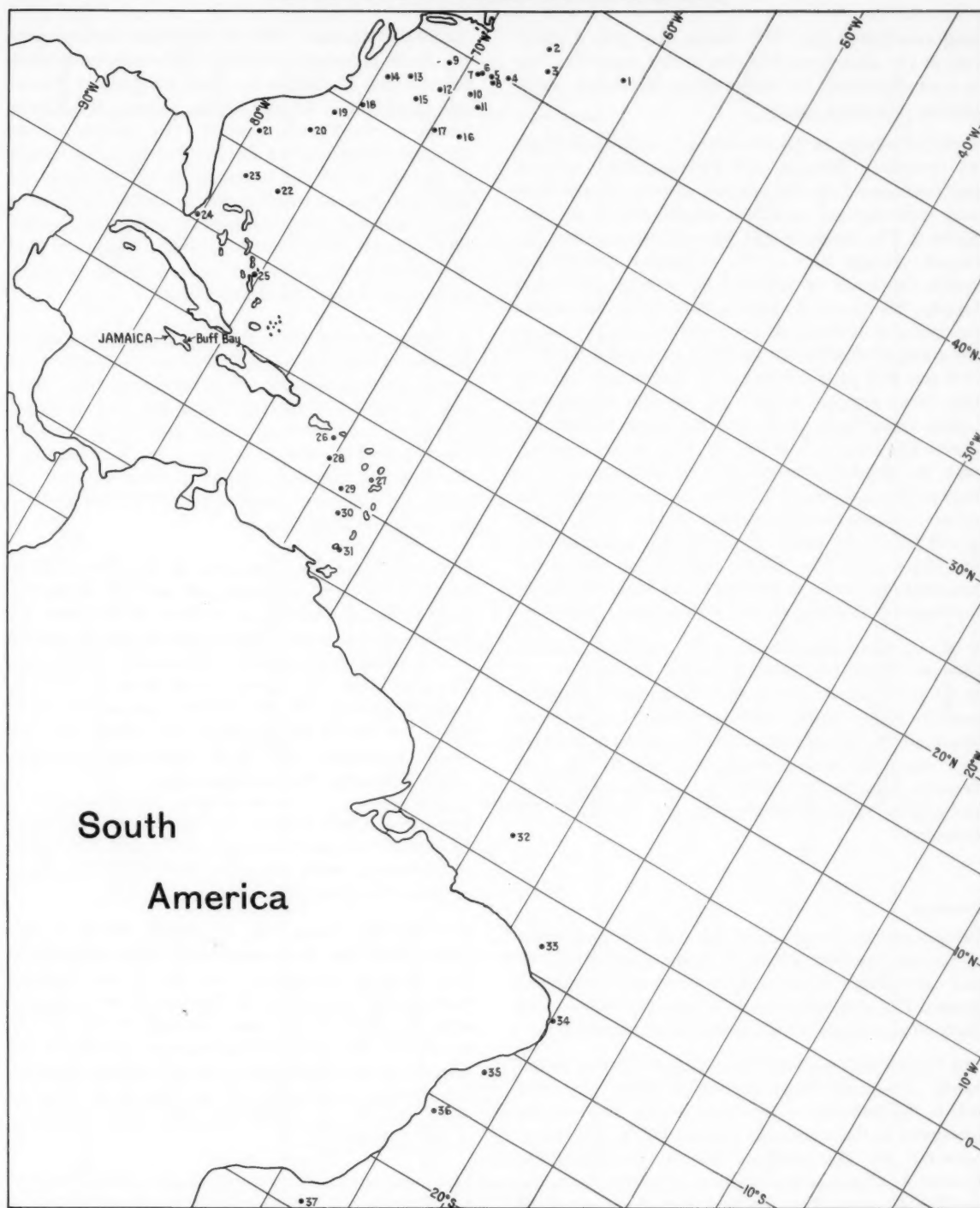
*Globigerinoides sacculifera* appears somewhat more sensitive to the temperatures of the surface waters. No specimens were found in samples with surface temperatures of less than 60° F., and nowhere did this species appear in abundance below 74° F. The larger specimens, which average over 0.85 mm. in length, occur in abundance only at surface temperatures above 78° F. This species has always been regarded as limited to tropical waters, and from these plots this fact can be substantiated.

*Globigerinoides rubra* occurs throughout the temperature range, as does *Orbulina universa*, but it is abundant only in samples from localities where the surface temperatures are above 70° F.

#### Salinity

That the salt content of sea water is one of the chief factors in controlling the life in the sea has been a

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TEXT-FIGURE 1

INDEX MAP OF SAMPLES STUDIED

(From U. S. Hydrographic Office Chart no. 2180a. For corresponding "Albatross" stations see Table 1.)



long established fact. This factor may play a direct role in the abundance and size of the organisms, but is itself dependent on temperature, circulation, evaporation, and other forces.

A plot of salinity in the Atlantic was made from Chart VI (Sverdrup, Johnson, and Fleming, 1942) along a line represented by the samples studied. This in turn was superimposed over the graphs shown in text-figure 2. The crests in text-figure 2, representing the largest average sizes of the organisms studied, fall within the limits of 35.5 and 37 parts per thousand salinity. The crests at about latitude 13° S. fall within the limits of 36.5 and 37 parts per thousand, whereas the northern maxima are included within the limits of 35.5 and 36.5 parts per thousand. The largest individuals, from samples 33 and 35, are also represented within these limits. However, the lower salinity between latitudes 5° and 10° N. does not correspond with the smaller average sizes of the organisms as shown in text-figure 2. The low for the average size occurs between the Equator and latitude 5° S., which is still within the limits of salinity that accounted for the larger sizes. The sudden drop in the size of the organisms indicated at the north end of the graphs in text-figure 2 coincides with a similar drop in salinity.

It can be stated that the size of the organisms is probably not affected by salinities within the range of 34 to 37 parts per thousand, but the larger individuals tend to favor salinity between 36 and 37 parts per thousand. The two localities where abundance of forms was noted, between latitudes 13° and 20° N. and between latitudes 30° and 34° N., are also areas where the salinity ranges between 35.5 and 36.5 parts per thousand.

#### Circulation

Pelagic species, being at the mercy of the movements of the seas for their dispersal, should show some size and abundance relationships to these circulating waters. The systems of currents affecting the areas of study of this paper are presented in text-figure 3.

The largest and most obvious of these systems is the North Equatorial Current, which flows westward within the latitudes of the trade winds. This current bifurcates in the vicinity of latitude 20° N. and longitude 60° W. The northern branch, paralleling the Greater Antilles and the Bahamas, is referred to as the Antilles Current. The southern fork flows south of the Greater Antilles through the Caribbean Sea and into the Gulf of Mexico. In this current there is mixing with waters flowing northwestward from the South

Equatorial Current after its deflection northward by the South American continent. These waters circulate through the Caribbean Sea and the Gulf of Mexico and re-enter the Atlantic Ocean through the Florida Straits as the Florida Current. The junction of the Florida Current and the Antilles Current in the vicinity of latitude 30° N. and longitude 70° W. produces the true Gulf Stream, which flows parallel to the coast of North America before turning east across the Atlantic. The southern deflection of the South Equatorial Current flows south along the coast of South America, where it is termed the Brazil Current.

A comparison between the size distributions of the pelagic species (text-fig. 2) and the patterns of the ocean currents presents many interesting facts. Samples 33 and 34, which fall in the low part of all the size graphs, are close enough to shore so as not to be affected by the currents in that area. It is here that the South Equatorial Current is bifurcated by the continent, and these samples are not included within the influence of its forces.

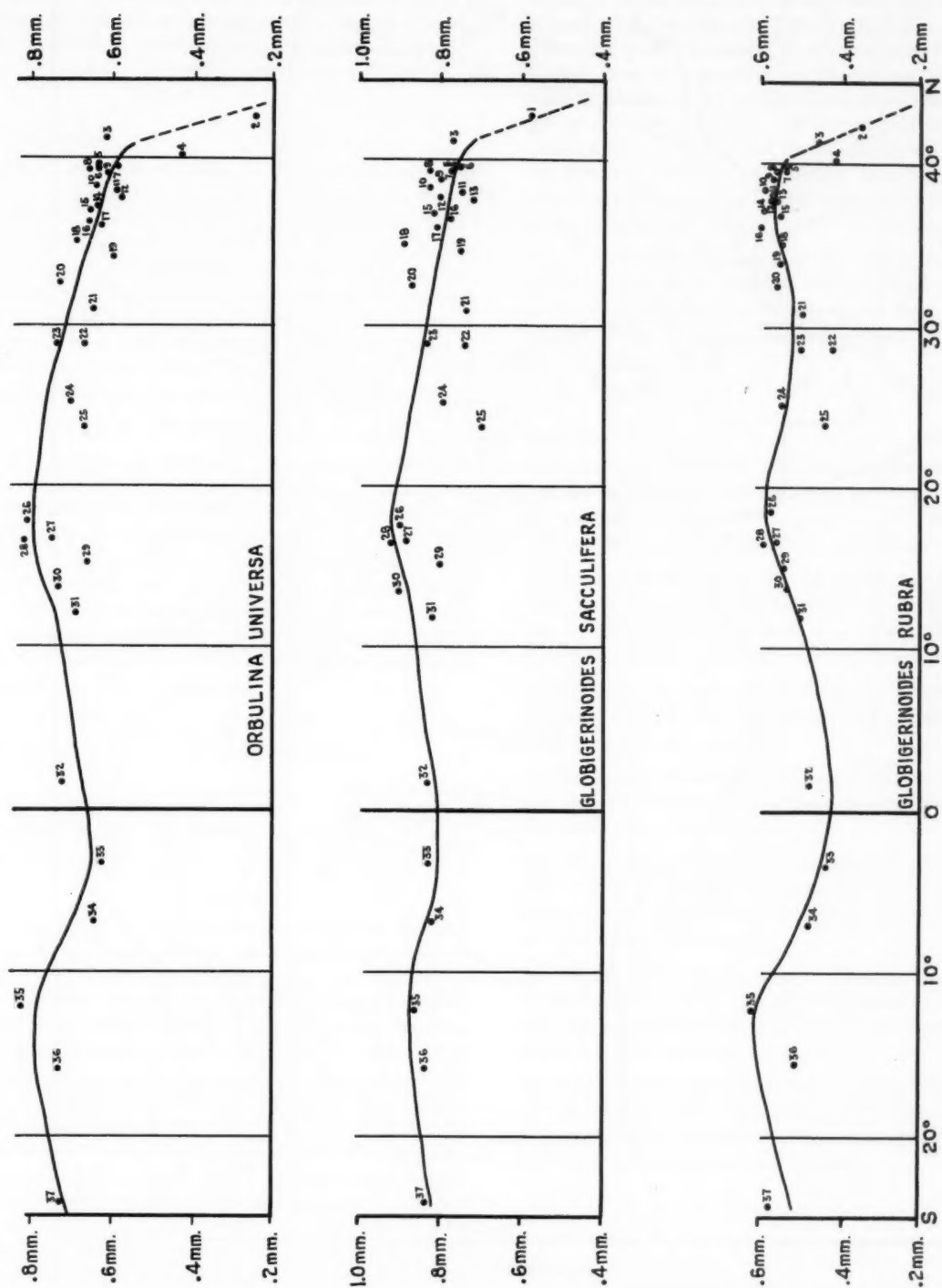
The crest of the size curves (text-fig. 2) in the southern latitudes is closely associated with and falls within the warmer Brazil Current as it flows south along the South American coast. This current is also responsible for the higher temperatures and salinities in this area. The crest of the size curves (text-fig. 2) in the northern latitudes between 15° and 20° N. is also seen to be in the direct line of the mixing of the waters from the North Equatorial and South Equatorial Currents, where they enter the Caribbean Sea.

Sample 25, which is below the size-variation curves of all three of the species studied, is situated well within the Bahama Islands, out of the direct influence of any of these circulating currents.

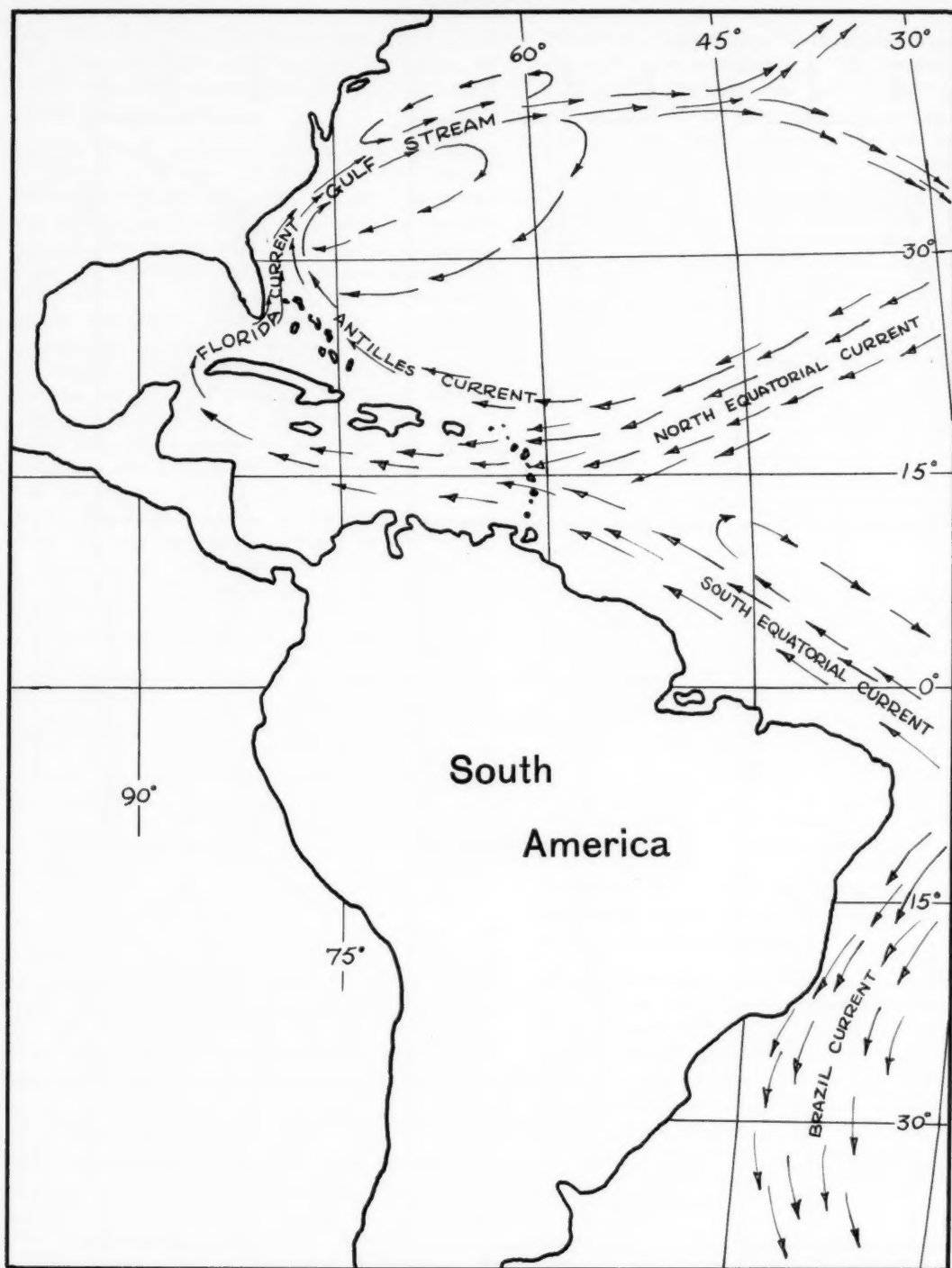
Two localities have been mentioned earlier in this paper where the three species are particularly abundant, between latitudes 13° and 20° N. and between latitudes 30° and 34° N. If these areas are compared with the chart of the ocean currents, it can be observed that the more southerly area is situated at the junction of the North and South Equatorial Currents, and that the more northerly area lies at the junction of the Florida and Antilles Currents, at the beginning of the Gulf Stream.

Many ecologic factors, including many of the chemical and physical properties necessary to support life in the oceans, can be traced in some way to the effects of the circulating currents. The availability of food for organisms is also closely associated with the surface

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TEXT-FIGURE 2  
SIZE VARIATION WITH LATITUDE



TEXT-FIGURE 3

CURRENTS IN THE WESTERN ATLANTIC OCEAN  
(Information from Sverdrup, Johnson and Fleming.)

## ECOLOGY OF PELAGIC FORAMINIFERA

circulation. The circulation thus appears to have a direct as well as an indirect relationship to the size and abundance variations found in pelagic species.

### AN APPLICATION

Samples were not available for the full application of the facts noted in this paper. In order to do this, a collection as complete as possible should be made from Tertiary horizons parallel to the coasts. In this way the size and abundance variations could be plotted and certain ecologic facts deduced concerning conditions in the seas in these former times. However, material from the Miocene of Buff Bay, Jamaica, B.W.I., has been studied, and an attempt has been made to work out the ecology of that time on the basis of the findings of this paper.

In this Miocene material, the same three species show much smaller average sizes than those found in the Recent samples. This result corresponds in general with those of Cushman and Harris (1927) and Cushman and Todd (1941), in which Miocene specimens of *Globorotalia* and *Bolivina* were found to be of smaller size than Recent specimens. To state that this is an evolutionary trend in the Globigerinidae would be unwarranted on the basis of measurements in samples from one locality.

The size and abundance of these species in the Buff Bay material were found to be as follows:

<i>Orbulina universa</i>	<i>Globigerinoides sacculifera</i>	<i>Globigerinoides rubra</i>
Diameter 0.50 mm.	Length 0.51 mm.	Length 0.22 mm.
Frequent	Width 0.41 mm.	Width 0.18 mm.
	Ratio 1:12	Ratio 1:12
	Rare	Rare

An explanation of this smaller size based on the ecologic factors discussed in this paper would indicate that the Miocene seas of this region were highly unfavorable for the growth of pelagic foraminifera. Such small sizes would signify conditions similar to those off North America above latitude 40° N. today. Thus, reduced temperature, lower salinity, and poor circulation of the surface waters are indicated. That the surface waters were above 60° F. is evidenced by the presence of *Globigerinoides sacculifera*. That the salinity was greatly reduced, below 34 parts per thousand, is indicated by the smaller sizes and rarer occurrence of the three species. This reduced salinity can also be inferred from other geologic data. Schuchert (1935) reports an uplift of some 2000 feet in central Jamaica in Miocene time. This uplift would have increased the

turbidity of the water and greatly increased the flow of fresh water into the sea. That the Buff Bay material represents poor circulation is also suggested by the smaller sizes and numbers of the species. Buff Bay, being on the north side of the island, would have been out of the direct influence of the circulating waters between the Caribbean and the Pacific Ocean through the Panama gateway. Its location would also have been sheltered somewhat by the larger northern islands of the Greater Antilles.

The large and varied fauna of this material suggests moderate depths of 100 to 200 fathoms (Cushman and Jarvis, 1930), but, as previously stated, these pelagic species merely indicate some connection with open-sea conditions.

### SUMMARY

The species studied show a decrease in size northward and southward from two localities, between latitudes 15° and 20° N. and between latitudes 10° and 15° S. This pattern is shown graphically in text-figure 2.

Abundance of the three species is obvious between latitudes 13° and 20° N. and between latitudes 30° and 34° N. *Orbulina universa* is generally abundant throughout the area studied.

Variations in size and abundance have no direct relationship to depth, but the presence of pelagic forms indicates open-sea conditions.

*Orbulina universa* and *Globigerinoides rubra* are less sensitive to variations in surface temperature than *Globigerinoides sacculifera*.

The larger individuals of the three species prefer salinities of 36 to 37 parts per thousand, but variations from 34 to 37 parts per thousand in no way appear to affect the size of the organisms.

Abundance and size are closely related to circulating currents of the ocean, the most abundant specimens and the largest sizes occurring within the direct influence of ocean currents.

Miocene samples from Buff Bay, Jamaica, show that conditions were more adverse to pelagic forms in that area at that time. Reduced salinity, lower temperature and inferior circulation are indicated.

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**ABSTRACT:** The genus *Globorotalia* is reviewed and redefined on the basis of the structure of its species. Remarks are also made on the structure of *Globotruncana* and *Globigerina*. The interrelationships of all three are discussed.

## The structure of *Globorotalia*

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*The Hague*

The type species of *Globorotalia* is *Globorotalia tumida* (Brady) (text-fig. 3). The characters of the type are as follows: Test hyaline, crystalline; pores fine and evenly distributed over the entire dorsal and ventral surface of each chamber, but absent from the area around the aperture; this area is connected with the marginal area, which is also free of pores. Margin distinctly subcarinate, hyaline, poreless. Umbilicus nearly closed, as the ventral walls of the chambers in the center almost touch the former walls. Aperture a large crescent at the ventral suture. Septal foramina consisting of the former apertures. Dorsal sutures oblique and rounded. These characters are also the characters of "*Truncorotalia*" (text-fig. 4).

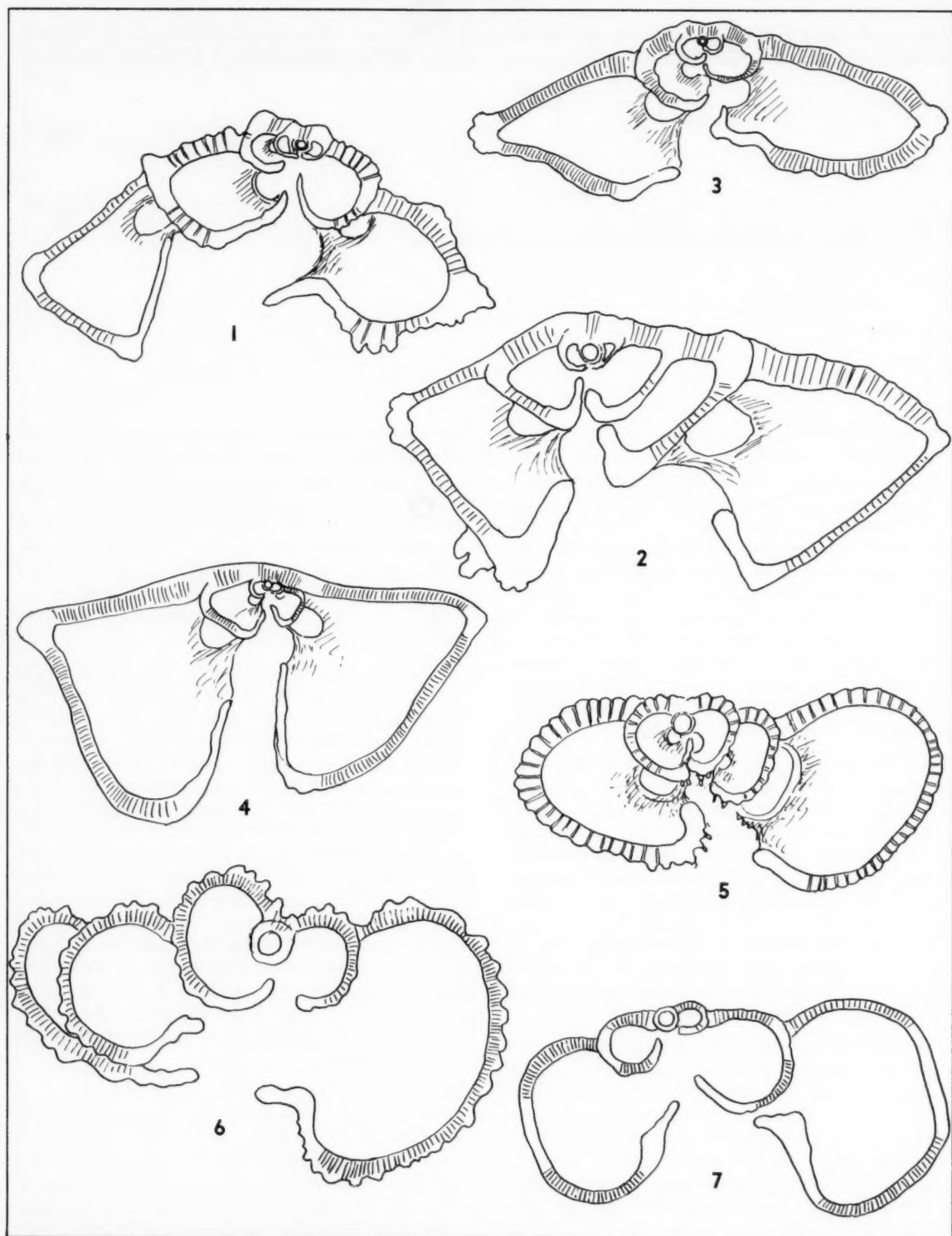
These characters separate *Globorotalia* clearly from all genera of the Globigerinidae but not so clearly from those of the Globotruncanidae. In all true globigerines, the walls are pierced all over by pores, which are also distinct but may be coarser in advanced species. No trace of a poreless area around the aperture is found in any of the globigerines, and a poreless carinate margin is never developed. In Cretaceous globigerines, the aperture is covered by a more or less well developed tenon, and opens into the central umbilicus. In Tertiary species, the aperture becomes sutural and the umbilicus may be closed.

In the Globotruncanidae, the aperture consists of a proto- and a deuteroforamen in primitive forms such as *Rotalipora* and *Thalmaninella*. In more advanced groups, these two apertures may fuse into a foramen compositum, opening into the open umbilicus. In all Globotruncanidae, the margin is poreless, even in those forms in which a carinate margin is absent, such as *Globotruncana globigerinoides* Brotzen (see also text-fig. 7).

The genus *Rugoglobigerina*, described in recent literature, comprises two quite different groups. One group has a poreless margin and consequently is an aberrant member of the Globotruncanidae (see text-fig. 7); the other group has pores all over the margin, and is an aberrant *Globigerina* of the type of *Globigerina cretacea* (text-fig. 6). The type species of *Rugoglobigerina*, *Globigerina rugosa* Plummer, belongs to the latter group. The genus *Rugoglobigerina* therefore has no real taxonomic status.

When we consider the characters of the groups here described, we are led to the conclusion that true *Globorotalias* show many characters that are typical of the Globotruncanidae, especially the Globotruncanidae that have a single keel, such as those of the Maestrichtian, and the Globotruncanidae with radiate sutures on the ventral side, such as *Marginotruncana* Hofker (1956). The oblique sutures on the dorsal side, the fine but distinct pores, the poreless area connected with a poreless margin, are common to both. All these typical characters are lacking in the Globigerinidae. The only difference between true *Globorotalias* and the Globotruncanidae is that in *Globorotalia* the aperture is not umbilical but sutural, and, in connection with this character, the umbilicus is closed or nearly so. We therefore suggest that the genus *Globorotalia* developed from the unicarinate Maestrichtian species of *Globotruncana*.

In the Lower Tertiary, a group of globigerines is found in which the dorsal side of the test is more or less flattened. These forms are grouped around what has been called "*Globorotalia*" *centralis* Cushman and Bermudez (text-fig. 5). Close study of sections of these species reveals that they do not show the characters of *Globorotalia*, but those of *Globigerina*, with



## STRUCTURE OF GLOBOROTALIA

a nearly closed umbilicus and a sutural aperture. The poreless margin, so typical of true *Globorotalia*, is absent. These types are therefore actually globigerines in which the test has become more or less compressed and the umbilicus more or less closed. They must be removed from *Globorotalia*.

True *Globorotalias* appear at the boundary between the Maestrichtian and the Danian (or Tertiary). Some species of so-called *Globorotalia* recorded from older beds of the Cretaceous should be restudied in order to determine their true taxonomic status. The oldest known true *Globorotalias* are: *Globorotalia mosae*, from the Mc-Md beds of Maestricht (Hofker, 1955); *Globorotalia membranacea* (Ehrenberg), from the lowermost Paleocene and the Danian; and *Globorotalia velascoensis* (Cushman), from the lowermost Paleocene and probably Danian. Of these three species, *Globorotalia mosae* Hofker and *Globorotalia membranacea* (Ehrenberg) are true *Globorotaliinae*, with a nearly closed umbilicus. *Globorotalia velascoensis* (Cushman) shows a striking difference, however, for here the umbilicus is wide open, and the chambers open into it just as they do in the *Globotruncanidae* (compare text-figs. 1 and 2). Consequently, *Globorotalia velascoensis*, which shows all the characters of a true *Globorotalia* except for the wide umbilicus, represents a type that is transitional between a true *Globotruncana* (*Marginotruncana*) and a true *Globorotalia*. Moreover, if sections of specimens of this species were found in chalk, associated with globigerines of Tertiary habitus (*Globigerina linaperta*, *Globigerina pseudobulloides*, *Globigerina trilocu-*

*linoides*), they might suggest that some *Globotruncanas* occur in the Danian associated with these Tertiary globigerines. The author has studied several of these sections in a rock that is certainly of Danian age, although the occurrence of these so-called "Globotruncanas" is contrary to such an age-determination.

### CONCLUSIONS

- a) The *Globotruncanidae* (*Marginotruncana*) and *Globorotalia* developed transitional forms at the Cretaceous/Danian/Tertiary boundary.
- b) *Globorotalia* was developed from members of the *Globotruncanidae* with a single keel and radiate ventral sutures (*Marginotruncana*).
- c) True *Globorotalia* is characterized by a poreless keel; the group related to "*Globorotalia*" *centralis* does not belong to *Globorotalia* but to the *Globigerinidae*.
- d) *Rugoglobigerina* as emended by Gandolfi and others comprises two groups, one of *Globotruncana* ancestry, the other of *Globigerina* ancestry; the type species is an aberrant *Globigerina*.

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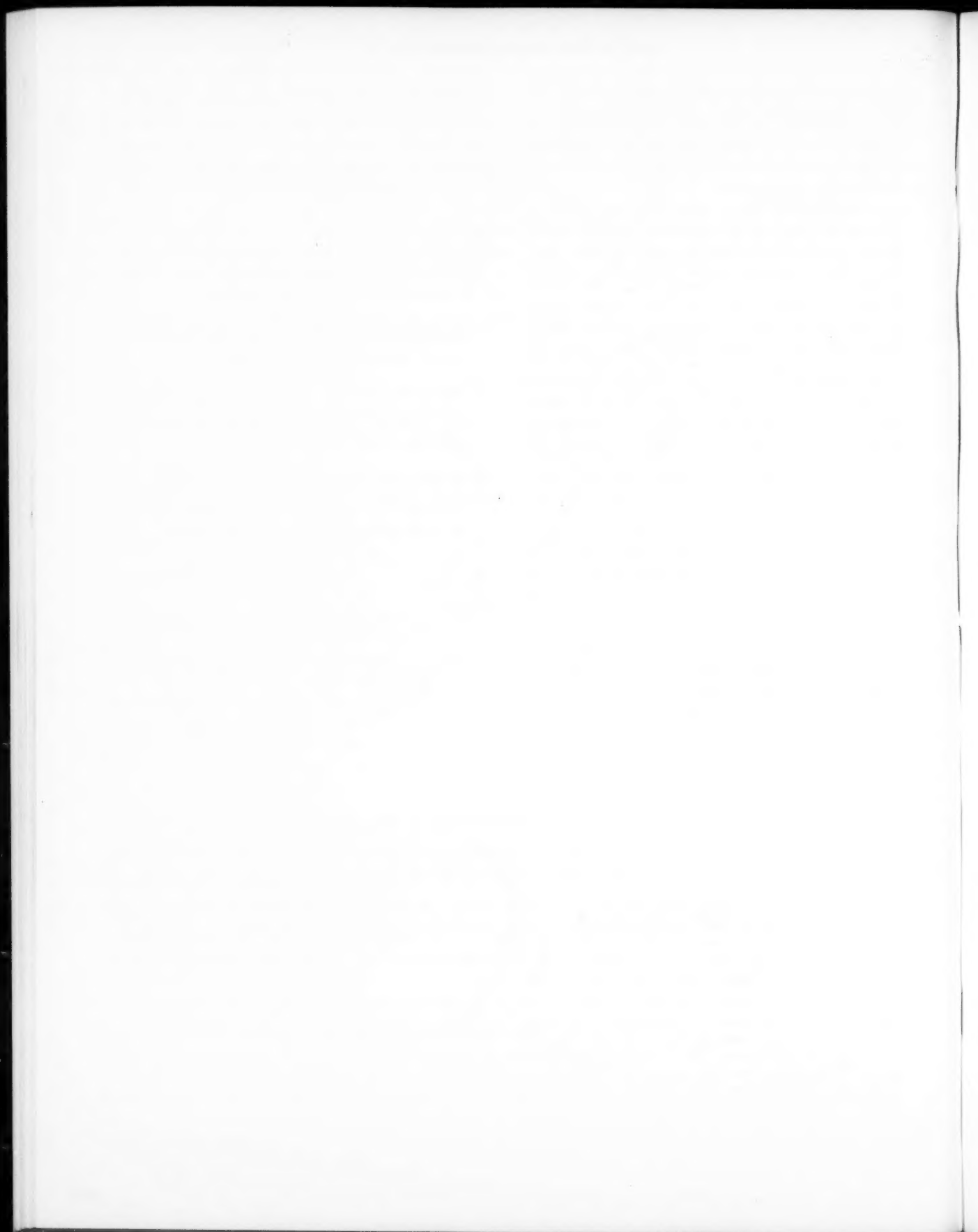
### TEXT-FIGURES 1-7

All figures are transverse sections,  $\times 240$ .

1, *Globotruncana stuartiformis* Dalbiez; Navarro group, Jones' Crossing, Onion Creek, north of Austin, Texas. 2, *Globorotalia velascoensis* (Cushman); Velasco shale, Arago road crossing halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. 3, *Globorotalia tumida* (Brady); Recent, near Frederiksted, Saint Croix, Virgin Islands, in 500 fathoms. 4, *Globorotalia truncatulinoidea* (d'Orbigny); Recent, Challenger station off Tristan da Cunha, in about 3000 fathoms. 5, "*Globorotalia*" *barissanensis* LeRoy, one of the so-called *Globorotalias* of the group of "*Globorotalia*" *centralis* Cushman and Bermudez; Oligocene, unit 30-A, Ecuador. 6, *Globigerina rugosa* Plummer; Navarro group, Jones' Crossing, Onion Creek, north of Austin, Texas. 7, *Marginotruncana pura* Hofker; lower Campanian — upper Campanian boundary, boring north of Hannover, Germany.

There is striking resemblance between text-figures 1 and 2. Text-figures 3 and 4 show the typical features of true *Globorotalia*; 4 shows those of "*Truncorotalia*." Text-figure 5 is actually a *Globigerina* with flat dorsal side, because there is no poreless margin, although the species has been called *Globorotalia* in the literature. Text-figure 6 shows the type species of "*Rugoglobigerina*," which proves to be a *Globigerina* and therefore unrelated to *Globotruncana*. The species shown in text-figure 7 was also included in "*Rugoglobigerina*" by Gandolfi, but by its poreless margin it clearly shows its relationship to *Globotruncana* (*Marginotruncana*).





## Bibliography and index to new genera and species of Ostracoda for 1955

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Thirty-eight papers pertaining to ostracodes are known to have been published during the year 1955. This represents a decrease from the sixty-five ostracode papers now known to have been published in 1954. In 1955, sixteen new genera and subgenera were described, as opposed to thirty-seven in 1954, thirty-seven in 1953, fifty in 1952 and twenty-five in 1951. During 1955, ninety-two new species were described, in contrast to the 230 new species described in 1954, and 333 in 1953.

The writer is again grateful to the many ostracode workers who generously supplied him with reprints of their papers and of other papers as they appeared. He is particularly indebted to Dr. H. V. Howe, I. G. Sohn, Dr. M. K. Elias, Dr. A. J. Key and Robert W. Morris.

In the following bibliographies, general papers containing no new species of ostracodes are marked with an asterisk (\*).

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## NEW SUBGENERA, GENERA AND SUPRAGENERIC CATEGORIES IN 1955

In the alphabetically arranged list of genera, the order of the items given in each entry is as follows: Name of the genus, its author and date; name of the type species, its author and date; page and figure in the reference in which the genus is proposed; stratigraphic horizon and geographic locality of the type species (in parentheses); range and habitat of the genus; family affiliation, if noted in the paper in which the new genus is described.

The generic names *Pinella* and *Trilobella* Ivanova, 1955, are preoccupied. Dr. Ivanova advises (personal communication, letter dated June 22, 1956) that new names for these genera will be published in the "U.Sh." volume of the textbook "Principles of Paleontology," which is now being prepared for publication by the Paleontological Institute of the Academy of Sciences of the U.S.S.R.

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*Aurila* Pokorný, 1955; *Cythere convexa* Baird, 1850; pp. 17-19, text-figs. 8-11 (Recent, Mediterranean); Miocene—Recent, marine, Hemicytherinae.  
*Bekena* Gibson, 1955a; *B. diaphrovalvis* Gibson, 1955; p. 18, pl. 1, fig. 9a-d (Upper Devonian, Iowa); Upper Devonian, marine, Bairdiidae.  
*Clavofabellina* Martinsson, 1955; *C. incurvata* Martinsson, 1955; pp. 23-25, pl. 2, figs. 14-16, 19-20, 25 (Middle Silurian, Gotland); Middle Silurian, marine, Primitiopsidae.

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*Hemicytheria* Pokorný, 1955; *Cypridina folliculosa* Reuss, 1850; pp. 23-26, text-figs. 15-18 (Pliocene, Czechoslovakia); Pliocene, marine, Hemicytherinae.  
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*Morrisites* Gibson, 1955a (non Buckman, 1921) = *Morrisitina* Gibson, 1955b; *Morrisites gibbosus* Gibson, 1955; p. 21, pl. 1, fig. 7a-b (Upper Devonian, Iowa); Upper Devonian, marine, Beecherellidae.  
*Parajonesites* Ivanova, 1955; *P. notabilis* Ivanova, 1955; pp. 170-171, pl. 23, figs. 4-5 (Upper Ordovician, Russia); Upper Ordovician, marine, Primitiidae.  
*Pinella* Ivanova, 1955 (non Stephenson, 1941, Univ. Texas Publ. no. 4101, p. 324); *P. tenuispina* Ivanova, 1955; p. 173, pl. 22, figs. 7-8 (Middle Ordovician, Russia); Middle Ordovician, marine, Aechminidae.  
*Pterygocythere* Hill, 1955; *Cypridina alata* Bosquet, 1847; pp. 819-821, pl. 98, fig. 7a-b; pl. 100, fig. 4a-c (Upper Cretaceous, Europe); Upper Cretaceous—Oligocene, marine, Cytheridae.  
*Quadrilobella* Ivanova, 1955; *Q. recta* Ivanova, 1955; pp. 174-175, pl. 23, figs. 9-11 (Middle Ordovician, Russia); Middle Ordovician, marine, Tetradellidae.  
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## NEW SPECIES, SUBSPECIES AND VARIETIES IN 1955

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*Aparchitella major* Ivanova 1955; p. 166, pl. 22, figs. 1-3 (Upper Ordovician, Russia); Leperditellidae.  
*Bairdia extenda* Gibson, 1955a; p. 16, pl. 1, fig. 18 (Upper Devonian, Iowa); Bairdiidae.



- Bairdia hypsoconcha* Gibson, 1955a; p. 14, pl. 1, fig. 16 (Upper Devonian, Iowa); Bairdiidae.
- Bairdia lanceolata* Gibson, 1955a; p. 18, pl. 1, fig. 11 (Upper Devonian, Iowa); Bairdiidae.
- Bairdia merivia* Benson, 1955; p. 1033, pl. 107, figs. 7, 12 (Lower Mississippian, Missouri); Bairdiidae.
- Bairdia notoconstricta* Gibson, 1955a; p. 15, pl. 1, fig. 17a-b (Upper Devonian, Iowa); Bairdiidae.
- Bairdia rockfordensis* Gibson, 1955a; p. 17, pl. 1, fig. 8 (Upper Devonian, Iowa); Bairdiidae.
- Bairdia subtila* Gibson, 1955a; p. 16, pl. 1, fig. 14a-b (Upper Devonian, Iowa); Bairdiidae.
- Basslerites bosqueti* Key, 1955; p. 130, pl. 18, figs. 1-2; pl. 19, figs. 3-4 (Miocene, France); Cytheridae, Cytherinae.
- Beecherella trapezoides* Gibson, 1955a; p. 21, pl. 1, fig. 5a-b (Upper Devonian, Iowa); Beecherellidae.
- Bekena diaphrovalvis* Gibson, 1955a; p. 19, pl. 1, fig. 9a-d (Upper Devonian, Iowa); Bairdiidae.
- Campylocythere concinnoidea* Swain, 1955; p. 636, pl. 62, fig. 5a-d; text-figs. 36a, 39 (8a-b) (Recent, San Antonio Bay, Texas); Cytheridae.
- Caudites monsmirabiliensis* Apostolescu, 1955a; p. 251, pl. 2, figs. 33-34 (Eocene, France); Cytheridae, Cytherinae.
- Clavofabella incurvata* Martinsson, 1955; p. 26, pl. 2, figs. 14-16, 19-20, 25 (Middle Silurian, Gotland); Primitiopsidae.
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- Cytherelloidea dameriacensis* Apostolescu, 1955a; p. 244, pl. 1, fig. 7 (Eocene, France); Cytherellidae.
- Cytheretta crassivenia* Apostolescu, 1955a; p. 261, pl. 5, figs. 77-79 (Eocene, France); Cytheridae, Cytherettinae.
- Cytheretta grignonensis* Apostolescu, 1955a; p. 262, pl. 5, figs. 80-83 (Eocene, France); Cytheridae, Cytherettinae.
- Cytheridea pernota* Oertli and Key, 1955; p. 19, pl. 1, figs. 1-13; text-fig. 2 (Oligocene, Belgium); Cytheridae.
- Cytherideis neauphensis* Apostolescu, 1955a; p. 265, pl. 6, figs. 98-99 (Eocene, France); Cytheridae, Cytherideisinae.
- Cytherura radialirata* Swain, 1955; p. 626, pl. 63, fig. 8a-b; pl. 64, fig. 3; text-fig. 35a (Recent, San Antonio Bay, Texas); Cytheridae, Cytherurinae.
- Eocytheropteron parnensis* Apostolescu, 1955a; p. 259, pl. 4, figs. 66-67 (Eocene, France); Cytheridae, Loxoconchinae.
- Erpetocypris reptans aulicae* Lüttig, 1955, new subspecies; pp. 159-160, pl. 18, fig. 1 (Pleistocene, Germany); Cyprididae.
- Euglyphella subquadrata* Gibson, 1955a; p. 23, pl. 2, fig. 8a-b (Upper Devonian, Iowa); Ropolonellidae.
- Euprimitia helenae* Ivanova, 1955; p. 169, pl. 23, figs. 1-3 (Upper Ordovician, Russia); Primitiidae.
- Eurichilina [=Eurychilina] sibirica* Ivanova, 1955; p. 172, pl. 22, fig. 9 (Middle to Upper Ordovician, Russia); Primitiidae.
- Falunia girondica* Grékoff and Moyes, 1955; pp. 333-334, pl. 19B, figs. 1-2; text-fig. 1 (Miocene, France); Loxoconchinae.
- Graphiadactyllis fernglenensis* Benson, 1955; p. 1033, pl. 108, figs. 5, 11, 13, 15-17 (Lower Mississippian, Missouri); Quasillitidae.
- Graphiadactyllis moridgei* Benson, 1955; p. 1035, pl. 108, figs. 1-2 (Lower Mississippian, Missouri); Quasillitidae.
- Haplocytheridea basiliensis* Oertli, 1955; p. 26, pl. 1, figs. 25-33 (Oligocene, Switzerland); Cytheridae.
- Haplocytheridea henisensis* Key, 1955; p. 25, pl. 1, figs. 17-22; text-figs. 1, 3 (Oligocene, Belgium); Cytheridae.
- Haplocytheridea perforata cambesensis* Key, 1955, new subspecies; p. 110, pl. 19, figs. 6-7 (Miocene, France); Cytheridae, Cytherideinae.
- Hemicythere frederica* Apostolescu, 1955a; p. 267, pl. 6, figs. 102-104 (Eocene, France); Trachyleberidae, Trachyleberinae.
- Hemicythere magnei* Key, 1955; p. 123, pl. 18, figs. 3-4 (Miocene, France); Cytheridae, Cytherinae.
- Jonesina biloba* Gibson, 1955a; p. 8, pl. 1, fig. 4a-c (Upper Devonian, Iowa); Kloedenellidae.
- Kirkbya fernglenensis* Benson, 1955; p. 1036, pl. 107, figs. 11, 13, 17-18 (Lower Mississippian, Missouri); Kirkbyidae.
- Kirkbya keiferi* Benson, 1955; p. 1037, pl. 107, figs. 14, 16 (Lower Mississippian, Missouri); Kirkbyidae.
- Kirkbyella devonica* Gibson, 1955a; p. 10, pl. 1, fig. 15 (Upper Devonian, Iowa); Kirkbyidae.
- Leguminocythereis inornata* Apostolescu, 1955a; p. 252, pl. 2, figs. 35-36 (Eocene, France); Cytheridae, Cytherinae.
- Leptocythere paracastanea* Swain, 1955; p. 640, pl. 62, fig. 7; pl. 63, fig. 1a-c; text-fig. 39 (5a-b) (Recent, San Antonio Bay, Texas); Cytheridae.
- Limnocythere duffi* Hornibrook, 1955; p. 269, text-figs. 1, 14, 34 (Recent(?), fresh-water, New Zealand).
- Loxoconcha matagordensis* Swain, 1955; p. 629, pl. 63, fig. 9a-b; pl. 64, fig. 1a-b; text-figs. 36, 39 (7a-b) (Recent, San Antonio Bay, Texas); Cytheridae, Loxoconchinae.

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- Macronotella punctulifera* Gibson, 1955a; p. 7, pl. 2, fig. 5 (Upper Devonian, Iowa); Aparchitidae.
- Monoceratina? levinsoni* Gibson, 1955a; p. 13, pl. 2, fig. 9a-c (Upper Devonian, Iowa); Acronotellidae.
- Morrisites gibbosus* Gibson, 1955a; p. 22, pl. 1, fig. 7a-b (Upper Devonian, Iowa); Beecherellidae.
- Pachydomella antedecens wolfarti* Krömmelbein, 1955b, new subspecies; p. 307, pl. 2, figs. 21-24 (Middle Devonian, Germany).
- Pachydomella cognata* Krömmelbein, 1955b; p. 308, pl. 2, fig. 25 (Middle Devonian, Germany).
- Paracytheretta multicarinata* Swain, 1955; p. 636, pl. 62, fig. 4; text-fig. 37a-b (Recent, San Antonio Bay, Texas); Cytheridae.
- Paracytheretta schoelleri* Key, 1955; p. 119, pl. 16, fig. 4; pl. 19, figs. 11-12 (Miocene, France); Cytheridae, Cytherettinae.
- Paracytheridea troglodyta* Swain, 1955; p. 623, pl. 61, fig. 7; pl. 62, fig. 9a-c; pl. 64, fig. 6; text-figs. 34a, 38 (6a-c) (Recent, San Antonio Bay, Texas); Cytheridae, Cytherideinae.
- Paracytheridea (Paracytheridea) tuberosa biensani* Key, 1955, new subspecies; p. 116, pl. 16, fig. 9 (Miocene, France); Cytheridae, Cytherideinae.
- Parajonesites notabilis* Ivanova, 1955; p. 171, pl. 23, figs. 4-5 (Upper Ordovician, Russia); Primitiidae.
- Perissocytheridea bicelliforma* Swain, 1955; p. 621, pl. 61, fig. 3a-b; pl. 64, fig. 4 (Recent, San Antonio Bay, Texas); Cytheridae, Cytherideinae.
- Perissocytheridea bicelliforma propsammia* Swain, 1955, new variety; p. 622, pl. 62, fig. 8a-b (Recent, San Antonio Bay, Texas); Cytheridae, Cytherideinae.
- Perissocytheridea brachyforma* Swain, 1955; p. 619, pl. 61, figs. 1a-e, 5a-g; text-figs. 33a, 39 (6a-c) (Recent, San Antonio Bay, Texas); Cytheridae, Cytherideinae.
- Perissocytheridea brachyforma excavata* Swain, 1955, new subspecies; p. 620, pl. 62, fig. 1a-c; text-fig. 33b (Recent, San Antonio Bay, Texas); Cytheridae, Cytherideinae.
- Perissocytheridea rugata* Swain, 1955; p. 622, pl. 61, fig. 4a-b; pl. 62, fig. 6a-b; text-fig. 33c (Recent, San Antonio Bay, Texas); Cytheridae, Cytherideinae.
- Pinella tenuispina* Ivanova, 1955; p. 173, pl. 22, figs. 7-8 (Middle Ordovician, Russia); Aechminidae.
- Plagionephrodes allotriovalvis* Gibson, 1955a; p. 25, pl. 2, fig. 3a-e (Upper Devonian, Iowa); Thlipsuridae.
- Plagionephrodes bicostalis* Gibson, 1955a; p. 24, pl. 2, fig. 1a-c (Upper Devonian, Iowa); Thlipsuridae.
- Plagionephrodes shideleri* Gibson, 1955a; p. 27, pl. 2, fig. 4a-d (Upper Devonian, Iowa); Thlipsuridae.
- Plagionephrodes werneri* Gibson, 1955a; p. 28, pl. 2, fig. 6a-d (Upper Devonian, Iowa); Thlipsuridae.
- Primitia abundans* Ivanova, 1955; p. 167, pl. 22, fig. 6 (Middle Ordovician, Russia); Primitiidae.
- Primitia latisulcifera* Ivanova, 1955; p. 168, pl. 22, fig. 4 (Middle Ordovician, Russia); Primitiidae.
- Protocythere propria emslandensis* Bartenstein and Burri, 1955, new subspecies; p. 439, pl. 29, figs. 1-2 (Lower Cretaceous, Germany).
- Pterygocythere howei* Hill, 1955; p. 812, pl. 98, fig. 2a-b; pl. 99, fig. 4a-d (Upper Oligocene to Middle Miocene, Mississippi and Maryland); Cytheridae.
- Pterygocythere murrayi* Hill, 1955; p. 822, pl. 100, fig. 5a-c (Middle Eocene to Oligocene, southeastern United States); Cytheridae.
- Pterygocythereis nadeauae* Hill, 1955; p. 818, pl. 98, fig. 6a-e; pl. 100, fig. 1a-h (Upper Cretaceous, Texas, Arkansas); Cytheridae.
- Quadrilobella arpilobata* Ivanova, 1955; p. 177, pl. 23, figs. 7-8 (Middle Ordovician, Russia); Tetradellidae.
- Quadrilobella elongata* Ivanova, 1955; p. 176, pl. 23, fig. 6 (Middle Ordovician, Russia); Tetradellidae.
- Quadrilobella recta* Ivanova, 1955; p. 175, pl. 23, figs. 9-11 (Middle Ordovician, Russia); Tetradellidae.
- Quasillites beachi* Gibson, 1955a; p. 29, pl. 2, fig. 7a-m (Upper Devonian, Iowa); Quasillitidae.
- Quasillites ellipticus* Gibson, 1955a; p. 31, pl. 1, fig. 3a-d (Upper Devonian, Iowa); Quasillitidae.
- Quasillites hackberryensis* Gibson, 1955a; p. 31, pl. 1, fig. 1a-d (Upper Devonian, Iowa); Quasillitidae.
- Roundyella fimbriamarginata* Gibson, 1955a; p. 11, pl. 2, fig. 2 (Upper Devonian, Iowa); Kirkbyidae.
- Roundyella mopacifa* Benson, 1955; p. 1037, pl. 107, figs. 4-6, 8, 10 (Lower Mississippian, Missouri); incertae sedis.
- Schizocythere tessellata hexagona* Apostolescu, 1955a, new subspecies; p. 258, pl. 4, figs. 62-65 (Eocene, France); Cytheridae, Cytherinae.
- Schmidtella dorsicostata* Ivanova, 1955; p. 165, pl. 22, fig. 5 (Middle Ordovician, Russia); Leperditellidae.
- Treposella stellata* Kesling, 1955a; pp. 277-279, pl. 2, figs. 1-3; pl. 3, figs. 1-6 (Middle Devonian, New York); Beyrichiidae.
- Triebelina boldi* Key, 1955; p. 107, pl. 14, figs. 7-8 (Miocene, France); Bairdiidae.
- Triginglymus grignonensis* Apostolescu, 1955a; p. 273, pl. 8, figs. 128-129 (Eocene, France); Trachyleberidae, Trachyleberinae.
- Triginglymus neauphlensis* Apostolescu, 1955a; p. 273, pl. 8, figs. 130-131 (Eocene, France); Trachyleberidae, Trachyleberinae.
- Triginglymus tenuistriatus* Apostolescu, 1955a; p. 274, pl. 8, figs. 132-135 (Eocene, France); Trachyleberidae, Trachyleberinae.
- Trilobella unica* Ivanova, 1955; p. 179, pl. 23, figs. 12-14 (Middle Ordovician, Russia); Tetradellidae.
- Tyrrhenocythere pignattii* Ruggieri, 1955; p. 698, text-figs. 1, 2, 5, 5a (Recent, Italy); Trachyleberidae, Hemicytherinae.
- Whipplella cenisa* Kremp and Grebe, 1955; p. 153, pl. 16, figs. 3-4; text-figs. 2 (4-6), 3 (11) (Carboniferous, Germany).

NEW NAMES IN 1955

- Hermanites* Puri, 1955; p. 558; new name for *Hermania* Puri, 1954 (non Monterosato, 1844).  
*Morrisitina* Gibson, 1955b; p. 1069; new name for *Morrites* Gibson, 1955a (non Buckman, 1921).  
*Bairdia epicypa* Kesling and Kilgore, 1955; p. 189; new name for *Bairdia gibbera* Kesling and Kilgore, 1952 (non Morey, 1935).  
*Monsmirabilia oblonga* Apostolescu, 1955b; p. 327; new name for *Bairdia subradiosa* Bosquet, 1850 (non *Cytherina subradiosa* Roemer, 1838).  
*Monsmirabilia subovata* Apostolescu, 1955b; p. 327; new name for *Bairdia perforata* Bosquet, 1850 (non *Cytherina perforata* Roemer, 1838).  
*Polyzygia gürichiana* Krömmelbein, 1955a; p. 371; new name for *Polyzygia gürichi* Krömmelbein, 1953 (non Polenova, 1952).

FORMS WITH NOMENCLATURA APERTA IN 1955

- Astenocypris*<sup>2</sup> sp., Swain, 1955; p. 604, pl. 59, fig. 7 (Recent, San Antonio Bay, Texas); Cyprididae, Cypridinae.  
*Bekena*<sup>2</sup> sp., Gibson, 1955a; p. 20, pl. 1, fig. 13 (Upper Devonian, Iowa); Bairdiidae.  
*Bythocypris*<sup>2</sup> sp., Swain, 1955; p. 611, pl. 59, fig. 4 (Recent, San Antonio Bay, Texas); Bairdiidae.  
*Candona* sp., Hornibrook, 1955; p. 273, text-figs. 13, 31 (Recent(?), fresh-water, New Zealand).  
*Cyprideis*<sup>2</sup> sp., Key, 1955; p. 110, pl. 15, figs. 8-9 (Miocene, France); Cytheridae, Cytherideinae.  
*Cypris* sp., Hornibrook, 1955; p. 271, text-figs. 8, 22, 27 (Recent(?), fresh-water, New Zealand).  
*Cythere*<sup>2</sup> sp., Swain, 1955; p. 642, pl. 64, fig. 16a-b (Recent, San Antonio Bay, Texas); Cytheridae.  
*Cytherelloidea* sp., Key, 1955; p. 103, pl. 14, fig. 4 (Miocene, France); Cytherellidae.  
*Darwinula* sp., Hornibrook, 1955; p. 271, text-figs. 15-16, 28 (Recent(?), fresh-water, New Zealand).  
*Eucythere* sp., Key, 1955; p. 115, pl. 16, fig. 7 (Miocene, France); Cytheridae, Cytherideinae.  
*Hemicythere* sp., Key, 1955; p. 125, pl. 18, figs. 11-12 (Miocene, France); Cytheridae, Cytherinae.  
*Hemicytherideis* sp., Swain, 1955; p. 632, text-fig. 32b (Recent, San Antonio Bay, Texas); Cytheridae, Xestoleberinae.  
*Hemicytherideis*<sup>2</sup> sp., Swain, 1955; p. 632, pl. 64, fig. 14 (Recent, San Antonio Bay, Texas); Cytheridae, Xestoleberinae.  
*Ilyocypris* n. sp., Lüttig, 1955; p. 162, pl. 17, figs. 10-12 (Pleistocene, Germany); Ilyocyprididae.  
*Jonesina*<sup>2</sup> sp., Gibson, 1955a; p. 9, pl. 1, fig. 6 (Upper Devonian, Iowa); Kloedenellidae.  
*Monoceratina*<sup>2</sup> sp., Swain, 1955; p. 637, pl. 61, fig. 6a-b; text-fig. 34b (Recent, San Antonio Bay, Texas); Cytheridae.

- Neomonoceratina* sp., Swain, 1955; p. 643, pl. 64, fig. 15 (Recent, San Antonio Bay, Texas); Cytheridae.  
*Pontocypris* sp., Hornibrook, 1955; p. 274, text-figs. 7, 33 (Recent(?), fresh-water, New Zealand).  
*Puriana* sp., Swain, 1955; p. 635, pl. 63, fig. 10 (Recent, San Antonio Bay, Texas); Trachyleberidae, Trachyleberinae.  
*Urocythereis* sp., Key, 1955; p. 125, pl. 19, fig. 2; pl. 17, fig. 15 (Miocene, France); Cytheridae, Cytherinae.  
*Youngiella*<sup>2</sup> sp., Gibson, 1955a; p. 7, pl. 1, fig. 12 (Upper Devonian, Iowa); Youngiellidae.

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- 1954 - *Stratigraphy of beds at the Devonian-Carboniferous boundary in the southern part of the Don-Medreditsa uplift*. Akad. Nauk SSSR, Doklady, vol. 94, no. 3, pp. 541-544 (several new species and varieties, MS. names and species "in coll.," all nomina nuda).

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## SUPPLEMENT TO NEW GENERA AND SUPRAGENERIC CATEGORIES IN 1950-1954

- Acratina* Egorov, 1953; *A. pestrozvetica* Egorov, 1953; pp. 43-44, pl. 20, figs. 1a-b, 2a-e, 3-4 (Upper Devonian, Russia); Upper Devonian, marine, Bairdiidae.
- Ilmenoindivisia* Egorov, 1954a; *I. wjadica* Egorov, 1954a; p. 20, pl. 3, figs. 12-18 (Upper Devonian, Russia); Upper Devonian, marine, Indivisiinae.
- Indivisia* (Zaspelova in litt.) Egorov, 1954a; *I. indistincta* (Zaspelova in litt.) Egorov, 1954a; p. 9, pl. 4, figs. 5-8, 13-14 (Upper Devonian, Russia); Upper Devonian, marine, Indivisiinae.



INDIVISIINAE Egorov, 1954a; new subfamily of Kloedenellidae, erected to include: *Indivisia* (Zaspelova *in litt.*) Egorov, 1954a; *Sulcoindivisia* Egorov, 1954a; *Ilmenoindivisia* Egorov, 1954a.

*Mossolovella* Egorov, 1953; *M. incognita* (Glebowskaia and Zaspelova *in litt.*) Egorov, 1953; pp. 45-46, pl. 15, figs. 1a-c, 2a-b, 3-11 (Upper Devonian, Russia); Upper Devonian, marine, Bairdiidae.

*Nannocythere* Schäfer, 1953; *N. remanei* Schäfer, 1953; pp. 352-353, text-figs. 1-6 (Recent, Helgoland); Recent, marine, Cytherinae.

*Plavskella* Samoilova, 1951; *P. famensis* Samoilova, 1951; p. 169, text-figs. 10-13 (Upper Devonian, Russia); Upper Devonian, marine, Kloedenellidae.

*Sulcoindivisia* Egorov, 1954a; *S. svinordensis* Egorov, 1954a; p. 15, pl. 3, figs. 1-6 (Upper Devonian, Russia); Upper Devonian, marine, Indivisiinae.

*Tambovia* Samoilova, 1951; *T. prima* Samoilova, 1951; p. 168, text-fig. 9 (Upper Devonian, Russia); Upper Devonian, marine, Kloedenellidae.

**SUPPLEMENT TO NEW SPECIES, SUBSPECIES AND VARIETIES IN 1950-1954**

*Acratia buregiana* Egorov, 1953; p. 39, pl. 21, fig. 1a-c (Upper Devonian, Russia); Bairdiidae.

*Acratia evlanensis* Egorov, 1953; p. 30, pl. 24, figs. 1a-d, 2-3, 4a-b, 5a-b, 6-7 (Upper Devonian, Russia); Bairdiidae.

*Acratia fursenkoi* Egorov, 1953; p. 33, pl. 26, fig. 1a-c (Upper Devonian, Russia); Bairdiidae.

*Acratia galinae* Egorov, 1953; p. 40, pl. 21, fig. 2a-c (Upper Devonian, Russia); Bairdiidae.

*Acratia gassanovae* Egorov, 1953; p. 41, pl. 21, fig. 4; pl. 22, figs. 4, 5a-b, 6, 8a-c, 9-12, 13a-b, 14 (Upper Devonian, Russia); Bairdiidae.

*Acratia hucrostaniensis* Egorov, 1953; p. 36, pl. 27, fig. 2a-b (Upper Devonian, Russia); Bairdiidae.

*Acratia konensis* Egorov, 1953; p. 33, pl. 26, fig. 4a-d (Upper Devonian, Russia); Bairdiidae.

*Acratia mayselae* Egorov, 1953; p. 37, pl. 25, figs. 1-8 (Upper Devonian, Russia); Bairdiidae.

*Acratia mossolovica* Egorov, 1953; p. 32, pl. 23, fig. 7a-b (Upper Devonian, Russia); Bairdiidae.

*Acratia petiniana* Egorov, 1953; p. 38, pl. 25, figs. 9a-b, 10 (Upper Devonian, Russia); Bairdiidae.

*Acratia pskovensis* Egorov, 1953; p. 42, pl. 22, figs. 1a-b, 2-3, 7 (Upper Devonian, Russia); Bairdiidae.

*Acratia schelonica* Egorov, 1953; p. 31, pl. 23, figs. 1a-c, 2a-c, 3, 4a-b, 5-6 (Upper Devonian, Russia); Bairdiidae.

*Acratia siratchoica* Egorov, 1953; p. 34, pl. 26, figs. 2a-d, 3a-b (Upper Devonian, Russia); Bairdiidae.

*Acratia tanaica* Egorov, 1953; p. 41, pl. 21, fig. 3a-b (Upper Devonian, Russia); Bairdiidae.

*Acratia tichonovitchi* Egorov, 1953; p. 39, pl. 19, fig. 5a-d (Upper Devonian, Russia); Bairdiidae.

*Acratia voronegiana* Egorov, 1953; p. 35, pl. 27, fig. 1a-c (Upper Devonian, Russia); Bairdiidae.

*Acratia zadonica* Egorov, 1953; p. 36, pl. 27, figs. 6a-c, 7 (Upper Devonian, Russia); Bairdiidae.

*Acratina ivanovoensis* Egorov, 1953; p. 45, pl. 20, fig. 5a-c (Upper Devonian, Russia); Bairdiidae.

*Acratina pestrozvetica* Egorov, 1953; p. 44, pl. 20, figs. 1a-b, 2a-e, 3-4 (Upper Devonian, Russia); Bairdiidae.

*Amphissites klarae* Egorov, 1953; p. 54, pl. 2, figs. 1-6 (Upper Devonian, Russia); Kirkbyidae.

*Bairdia birinae* Egorov, 1953; p. 25, pl. 12, figs. 3a-b, 4 (Upper Devonian, Russia); Bairdiidae.

*Bairdia eleziana* Egorov, 1953; p. 12, pl. 7, fig. 1a-d (Upper Devonian, Russia); Bairdiidae.

*Bairdia fobosi* Egorov, 1953; p. 27, pl. 11, figs. 5a-c, 6 (Upper Devonian, Russia); Bairdiidae.

*Bairdia galinae* Egorov, 1953; p. 25, pl. 8, figs. 3a-c, 4a-b (Upper Devonian, Russia); Bairdiidae.

*Bairdia irinae* Egorov, 1953; p. 19, pl. 10, fig. 1a-b (Upper Devonian, Russia); Bairdiidae.

*Bairdia ischimensis* Egorov, 1953; p. 20, pl. 12, fig. 4a-b (Upper Devonian, Russia); Bairdiidae.

*Bairdia ivanovae* Egorov, 1953; p. 9, pl. 5, figs. 2a-e, 3a-b, 4-5 (Upper Devonian, Russia); Bairdiidae.

*Bairdia kelleri* Egorov, 1953; p. 13, pl. 13, figs. 1a-d, 2a-c (Upper Devonian, Russia); Bairdiidae.

*Bairdia krestovnikovi* Egorov, 1953; p. 11, pl. 6, fig. 2a-d (Upper Devonian, Russia); Bairdiidae.

*Bairdia menneri* Egorov, 1953; p. 29, pl. 17, figs. 1a-d, 2a-b (Upper Devonian, Russia); Bairdiidae.

*Bairdia mossolovellaeformis* Egorov, 1953; p. 21, pl. 11, fig. 3a-b (Upper Devonian, Russia); Bairdiidae.

*Bairdia mossolovica* Egorov, 1953; p. 28, pl. 17, fig. 5a-b (Upper Devonian, Russia); Bairdiidae.

*Bairdia nalivkini* Egorov, 1953; p. 8, pl. 4, fig. 4a-c (Upper Devonian, Russia); Bairdiidae.

*Bairdia naumovae* Egorov, 1953; p. 23, pl. 11, figs. 1a-b, 2 (Upper Devonian, Russia); Bairdiidae.

*Bairdia petiniana* Egorov, 1953; p. 17, pl. 12, fig. 2a-d (Upper Devonian, Russia); Bairdiidae.

*Bairdia philippovae* Egorov, 1953; p. 17, pl. 10, fig. 5a-d (Upper Devonian, Russia); Bairdiidae.

*Bairdia plicatula* (Polenova *in litt.*) Egorov, 1953; p. 26, pl. 9, figs. 1a-d, 2-7 (Upper Devonian, Russia); Bairdiidae.

*Bairdia polenovae* Samoilova, 1951; p. 173, text-fig. 17 (Upper Devonian, Russia); Bairdiidae.

*Bairdia posneri* Egorov, 1953; p. 28, pl. 17, fig. 4a-d (Upper Devonian, Russia); Bairdiidae.

*Bairdia quarziana* Egorov, 1953; p. 22, pl. 13, figs. 1a-d, 2a-b, 3, 4a-b, 5a-b, 6; pl. 14, figs. 1a-b, 2, 3a-b, 4a-b, 8 (Upper Devonian, Russia); Bairdiidae.

*Bairdia quasisymmetrica* Egorov, 1953; p. 15, pl. 12, fig. 1a-c (Upper Devonian, Russia); Bairdiidae.

*Bairdia raabenae* Egorov, 1953; p. 20, pl. 12, fig. 4a-b (Upper Devonian, Russia); Bairdiidae.

*Bairdia rjabintini* Egorov, 1953; p. 16, pl. 6, fig. 3a-c (Upper Devonian, Russia); Bairdiidae.

*Bairdia sokolovi* Egorov, 1953; p. 11, pl. 6, fig. 1a-d (Upper Devonian, Russia); Bairdiidae.

## BIBLIOGRAPHY AND INDEX OF OSTRACODA

- Bairdia symmetrica* Egorov, 1953 (non Cooper, 1946); p. 14, pl. 12, fig. 2a-d (Upper Devonian, Russia); Bairdiidae.
- Bairdia tichomirovi* Egorov, 1953; p. 24, pl. 14, fig. 9a-b (Upper Devonian, Russia); Bairdiidae.
- Bairdia tokmovoensis* Egorov, 1953; p. 15, pl. 11, fig. 4a-d (Upper Devonian, Russia); Bairdiidae.
- Bairdia uchtaensis* Egorov, 1953; p. 18, pl. 10, figs. 2a-d, 3-4, 6a-b (Upper Devonian, Russia); Bairdiidae.
- Bairdia usatschovae* Egorov, 1953; p. 10, pl. 5, fig. 1a-e (Upper Devonian, Russia); Bairdiidae.
- Bythocypris nalivkini* Egorov, 1953; p. 50, pl. 18, figs. 1a-c, 2-3, 4a-e, 5a-c, 6a-c (Upper Devonian, Russia); Bairdiidae.
- Bythocypris polenovae* Egorov, 1953; p. 51, pl. 19, figs. 1a-d, 2a-c, 3a-b, 4 (Upper Devonian, Russia); Bairdiidae.
- Candona applanata* Pokorný, 1953; pp. 269, 336, 376, pl. 2, fig. 4; text-fig. 13 (Pliocene, Czechoslovakia); Candoninae.
- Candona fossulata* Pokorný, 1953; pp. 264, 333, 373, pl. 2, fig. 3; text-fig. 10 (Pliocene, Czechoslovakia); Candoninae.
- Candona (Lineocypris) hodonensis* Pokorný, 1953; pp. 273, 338, 378, pl. 1, figs. 5-6; text-figs. 15-16 (Pliocene, Czechoslovakia); Candoninae.
- Candona hoffi* Ferguson, 1953; p. 196, text-figs. 1-10 (Recent, Maryland).
- Candona multipora* Pokorný, 1953; pp. 267, 335, 374, pl. 2, fig. 2; pl. 6, fig. 6 (Pliocene, Czechoslovakia); Candoninae.
- Candona mutans* Pokorný, 1953; pp. 270, 337, 376, pl. 1, fig. 9; text-fig. 14 (Pliocene, Czechoslovakia); Candoninae.
- Cavellina tambovensis* Samoilova, 1951; p. 167, text-figs. 3-6 (Upper Devonian, Russia); Kloedenellidae.
- Cyprideis heterostigma sublittoralis* Pokorný, 1953, new subspecies; pp. 278, 341, 380, pl. 3, figs. 1-5; pl. 5, figs. 5, 8; text-figs. 17-22 (Pliocene, Czechoslovakia); Cytherideinae.
- Cytherura moravica* Pokorný, 1953; pp. 303, 350, 389, pl. 5, fig. 6; text-fig. 35 (Pliocene, Czechoslovakia); Cytherurinae.
- Eridoncha raychmani* Egorov, 1954b; p. 28, pl. 6, figs. 1-4 (Devonian, Russia).
- Eridoncha tokmovoensis* Egorov, 1954b; p. 27, pl. 6, figs. 5-6 (Devonian, Russia).
- Glyptolichwinella adelaidae* Samoilova, 1951; p. 172, text-fig. 14 (Upper Devonian, Russia); Kloedenellidae.
- Healdianella? plavskensis* Samoilova, 1951; p. 173, text-figs. 15-16 (Upper Devonian, Russia); Healdiidae.
- Herpetocypris agilis* Rome, 1954a; p. 26, text-fig. 7 (Recent, Belgium); Cypridinae.
- Herpetocypris caerulea* Rome, 1954a; p. 21, text-fig. 6 (Recent, Belgium); Cypridinae.
- Hollinella cerata* Egorov, 1953; p. 60, pl. 4, figs. 1a-d (Upper Devonian, Russia); Hollinidae.
- Hollinella evlanensis* Egorov, 1953; p. 58, pl. 2, figs. 8-9 (Upper Devonian, Russia); Hollinidae.
- Hollinella mirabilis* Egorov, 1953; p. 58, pl. 2, fig. 7a-b (Upper Devonian, Russia); Hollinidae.
- Hollinella pestrozvetica* Egorov, 1953; p. 59, pl. 4, fig. 2 (Upper Devonian, Russia); Hollinidae.
- Hollinella valentinae* Egorov, 1953; p. 56, pl. 3, figs. 1a-b, 2-4, 5a-b, 6a-d (Upper Devonian, Russia); Hollinidae.
- Hollinella verchovensis* Egorov, 1953; p. 59, pl. 4, fig. 3 (Upper Devonian, Russia); Hollinidae.
- Hollinella wetlosianiensis* Egorov, 1953; p. 59, pl. 2, fig. 10 (Upper Devonian, Russia); Hollinidae.
- Ilmenoindivisia wjadica* Egorov, 1954a; p. 21, pl. 3, figs. 12-18 (Upper Devonian, Russia); Indivisiinae.
- Indivisia indistincta* (Zaspelova in litt.) Egorov, 1954a; p. 12, pl. 4, figs. 5-8, 13-14 (Upper Devonian, Russia); Indivisiinae.
- Indivisia konensis* Egorov, 1954a; p. 13, pl. 4, figs. 9-12 (Upper Devonian, Russia); Indivisiinae.
- Indivisia semilukiana* Egorov, 1954a; p. 10, pl. 1, figs. 1-16 (Upper Devonian, Russia); Indivisiinae.
- Leptocythere moravica* Pokorný, 1953; pp. 300, 349, 388, pl. 2, fig. 10; pl. 6, fig. 5 (Pliocene, Czechoslovakia); Cytherinae.
- Leptocythere nodigera* Pokorný, 1953; pp. 299, 348, 387, pl. 2, figs. 5-6; text-fig. 34 (Pliocene, Czechoslovakia); Cytherinae.
- Limbata zaspelovae* Samoilova, 1951; p. 167, text-figs. 1-2 (Upper Devonian, Russia); Drepanellidae.
- Loxoconcha hodonica* Pokorný, 1953; pp. 308, 352, 391, pl. 5, figs. 1-2, 9; text-figs. 36-37 (Pliocene, Czechoslovakia); Loxoconchinae.
- Loxoconcha rhombovalis* Pokorný, 1953; pp. 310, 353, 392, pl. 4, fig. 6; pl. 6, fig. 1 (Pliocene, Czechoslovakia); Loxoconchinae.
- Mossolovella bairdiaeformis* Egorov, 1953; p. 46, pl. 17, fig. 3a-d (Upper Devonian, Russia); Bairdiidae.
- Mossolovella philippovae* Egorov, 1953; p. 48, pl. 15, figs. 12a-d, 13-14; pl. 16, figs. 2a-c, 3a-d, 5a-c (Upper Devonian, Russia); Bairdiidae.
- Mossolovella tichomirovi* Egorov, 1953; p. 49, pl. 16, figs. 1a-d, 6 (Upper Devonian, Russia); Bairdiidae.
- Nannocythere remanei* Schäfer, 1953; p. 353, text-figs. 1-6 (Recent, Helgoland); Cytherinae.
- Plavskella famensis* Samoilova, 1951; p. 169, text-figs. 10-13 (Upper Devonian, Russia); Kloedenellidae.
- Sulcoindivisia evlanovoensis* Egorov, 1954a; p. 19, pl. 1, figs. 17-20 (Upper Devonian, Russia); Indivisiinae.
- Sulcoindivisia semilukiana* Egorov, 1954a; p. 18, pl. 4, figs. 3-4 (Upper Devonian, Russia); Indivisiinae.
- Sulcoindivisia svinordensis* Egorov, 1954a; p. 16, pl. 3, figs. 1-6 (Upper Devonian, Russia); Indivisiinae.
- Sulcoindivisia verchovensis* Egorov, 1954a; p. 17, pl. 3, figs. 7-11 (Upper Devonian, Russia); Indivisiinae.
- Tambovia prima* Samoilova, 1951; p. 169, text-fig. 9 (Upper Devonian, Russia); Kloedenellidae.

# LEVINSON

## SUPPLEMENT TO FORMS WITH NOMENCLATURA APERTA IN 1950-1954

*Candona* sp., Pokorný, 1953; pp. 266, 334, 374, pl. 2, fig. 1; text-figs. 11-12 (Pliocene, Czechoslovakia); Candoninae.

*Candona* (*Lineocypris*) sp., Pokorný, 1953; pp. 275, 339, 379, pl. 1, fig. 7 (Pliocene, Czechoslovakia); Candoninae.

*Cavellina*<sup>2</sup> sp., Samoilova, 1951; p. 168, text-figs. 7-8 (Devonian, Russia); Kloedenellidae.

*Cypria* sp., Pokorný, 1953; pp. 262, 331, 371, pl. 6, fig. 7 (Pliocene, Czechoslovakia); Cypridinae.

*Leptocythere* sp., Pokorný, 1953; pp. 302, 350, 389, pl. 2, fig. 7 (Pliocene, Czechoslovakia); Cytherinae.

## SUPPLEMENT TO NOMINA NUDA IN 1954

*Cythere guriana* Dzvelaia and Maglaperidze, 1954 (*nomen nudum*); p. 156 (Tertiary(?), Russia).

*Lineocypris fahrioni* Turnovsky, 1954 (*nomen nudum*); pl. 14, fig. 9 (Upper Tertiary, Austria).

*Loxoconcha subgranifera* Turnovsky, 1954 (*nomen nudum*); pl. 14, fig. 5 (Upper Tertiary, Austria).

# Annotated bibliography of micropaleontology in Germany for 1955

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On the basis of many requests, it is believed that the annual bibliography which I began in "The Micropaleontologist" (1949, vol. 3, no. 2, pp. 14-15) should be continued. This bibliography comprises all results obtained in the field of micropaleontology published in Germany. The aim of my compilation has always been to give as complete a picture as possible, which consequently induced me to publish a complete index of papers printed during the years 1948 to 1954. My other bibliographies appeared in "The Micropaleontologist" as follows: 1950, vol. 4, no. 1, pp. 8-12; 1951, vol. 5, no. 2, pp. 6-11; 1952, vol. 6, no. 2, pp. 8-13; 1953, vol. 7, no. 2, pp. 22-28; and 1954, vol. 8, no. 2, pp. 17-26; and more recently in "Micropaleontology" (1955, vol. 1, no. 2, pp. 196-199). The bibliographies include only papers that are concerned with micropaleontology and microstratigraphy or that mention microscopic fossils.

Beginning with the present bibliography, I intend to present these bibliographies each year separate from my annual report. Brief annotations of each paper will also be given, stating its principal micropaleontological contribution. Articles that are important in taxonomy will be marked with an asterisk (\*).

BARTENSTEIN, H.

- \*1955 - *Taxionomische Revision der als Eoflabellina und Flabellamminopsis bezeichneten Foraminiferen*. Pal. Zeitschr., vol. 29, pp. 170-176, 2 pls.

*Eoflabellina* Payard, 1947, is considered to be a synonym of *Lenticulina*; *Flabellamminopsis* also appears to be invalid; neotypes are selected for *Lenticulina d'orbignyi* (Roemer) and *Triplasia munchisoni* Reuss.

BARTENSTEIN, H., AND BETTENSTAEDT, F.

- 1955 - *Exkursion europäischer Mikropaläontologen in Nordwest-Deutschland*. Erdöl und Kohle, vol. 8, p. 757.

Short reference concerning a several-days' excursion to type localities in northwestern Germany.

BARTENSTEIN, H., AND BURRI, F.

- \*1955 - *Die Jura-Kreide-Grenzschichten im schweizerischen Faltenjura und ihre Stellung im mittel-europäischen Rahmen*. Eclogae Geol. Helv., vol. 47, no. 2, pp. 426-443, 4 text-figs., 2 pls.

Microstratigraphic correlation of the Jurassic-Cretaceous boundary in Switzerland, northwestern Germany, and England; description of *Protocythere propria emslandensis*, n. subsp., in the Wealden 4 of northwestern Germany.

BHJARDMAJ, D. C., AND KREMP, G.

- \*1955 - *Die Sporenführung der Velener Schichten*. Geol. Jahrb., vol. 71, pp. 51-68, 1 pl., 5 tables.

An exact stratigraphic determination of two coal beds in the Westphalian D near Coesfeld is possible on the basis of palynology; description of four new species of spores.

BRELIE, G. VON DER

- 1955 - *Die Küstentorfe Ostfrieslands und ihre marine Beeinflussung*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 201-218, 4 text-figs.

Analyses of pollen and diatoms encountered in borings in the Ems estuary, in order to determine the amount of subsidence of the coast.

CAROZZI, A.

- 1955 - *Sédimentation récifale rythmique dans le Jurassique supérieur du Grand-Salève (Haute-Savoie, France)*. Geol. Rundschau, vol. 43, pp. 433-446, 3 text-figs.

In Upper Jurassic limestones of Haute-Savoie (thickness 225 meters), six types of coarse reef-limestones overlying fine-grained limestone have been distinguished; comparison with Recent reefs indicates sedimentation depths of 5 to 45 meters.

DANISCH, E.

- 1955 - *Über die Fauna der Kimmeridge- und Gigas-Schichten zwischen Engter und Venne*. Naturw. Ver. Osnabrück, Jahresber., vol. 27, pp. 54-74.

Lists of fossils belonging to the middle Malm, among them a few charophytes, seven foraminifera, and eight ostracodes.

DIETZ, C.

- 1955 - *Der geologische Bau der Kronsberg-Mulde zwischen Hannover und Lehrte*. Deutsch. Geol. Ges., Zeitschr., vol. 105, pp. 259-260, 1 text-fig.

- 1955 - *Exkursion zu den Tagesaufschlüssen im Bereich des Sarstedt-Lehrter Salzstockes*. Ibid., vol. 105, pp. 872-875, 2 text-figs.

Brief mention of microstratigraphic determinations by Bettenstaedt, Hiltermann, Pflug, and Thomson.

EINSELE, G., AND MOSEBACH, R.

- 1955 - *Zur Petrographie, Fossilhaltung und Entstehung der Gesteine des Posidonienschiefers im Schwäbischen Jura*. Neues Jahrb. Geol. Pal., Abh., vol. 101, pp. 319-430, 5 pls., 15 text-figs.

Short reference to microfossils, including foraminifera, in the Posidonian shales of the Swabian Lias.

EISENACK, A.

- \*1955 - *Chitinozoen, Hystrichosphaeren und andere Mikrofossilien aus dem Beyrichia-Kalk*. Senckenbergiana Lethaea, vol. 36, pp. 157-188, 5 pls., 13 text-figs.

Twelve Chitinozoa, including three new species, seven Hystrichosphaera (two new species), the foraminiferan *Blastamina polymorpha*, and some problematic fossils are described and figured, all from the Baltic Silurian, preserved in organic matter.

- \*1955 - *Ein Graptolith aus dem Beyrichia-Kalk*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 273-276, 6 text-figs.

Description of Silurian *Monograptus*.

- 1955 - *Mitteilung über die Aufbewahrung einiger früher von mir beschriebenen Originale und abgebildeten Exemplare von Graptolithen und Retioliten*. Ibid., pp. 277-278.

The type specimens that were not destroyed by war are kept in the Geological and Paleontological Institute of the University of Tübingen.

FAHRION, K.

- 1955 - *Die Mikrofauna des Jura der Bohrung Scherstetten 1*. Geol. Bavarica, no. 24, pp. 86-88.

Lists of foraminifera, ostracodes and other microfossils, and microstratigraphic remarks concerning drill cores from the Dogger and Malm of southern Germany.

FAHRION, H., AND STRAUB, E. W.

- 1955 - *Die Mikrofossilien der Molasse aus der Bohrung Scherstetten 1*. Ibid., no. 24, pp. 40-43, 1 table.

Stratigraphic and bionomic evaluation and vertical distribution of the principal microfossils (among them two foraminifera, eight ostracodes and three charophyte species) in the Miocene and Oligocene.

FIEBIG, H.

- 1955 - *Feinstratigraphisch-fazielle Untersuchungen der oberen Bochumer Schichten (oberes Westfal A) am linken Niederrhein*. Geol. Jahrb., vol. 70, pp. 611-656, 1 pl., 17 text-figs.

Brief references to Carboniferous foraminifera and ostracodes. (Abstract in Geol. Jahrb., vol. 71, pp. 171-174, 2 text-figs.)

- 1955 - *Die Ausbildung der Wittener (Esskohlen-) Schichten und die Gleichsetzung und einheitliche Benennung der Flöze im mittleren und westlichen Ruhrgebiet*. Glückauf, vol. 91, pp. 1181-1187, 2 text-figs.

Short reference to ostracodes of the Carboniferous belonging to the *Jonesina* group.

- 1955 - *Die Mikrofauna des Ruhrkarbons und ihre praktische Bedeutung für den Bergbau*. Deutsch. Geol. Ges., Zeitschr., vol. 105, pp. 550-551.

Short references to foraminifera, ostracodes and other microfossils of the Carboniferous.



# MICROPALAEONTOLOGY IN GERMANY

FIRBAS, F.

- 1954 - *Die Synchronisierung der Mitteleuropäischen Pollendiagramme*. Danmarks Geol. Unders., ser. 2, no. 80, pp. 12-21.

Summary and completion of his "Spät- und nacheiszeitliche Waldgeschichte Mitteleuropas."

FLÜGEL, H.

- \*1955 - *Zur Paläontologie des anatolischen Paläozoikums; III - Bryozoen aus dem Perm des Ala Dag*. Neues Jahrb. Geol. Pal., Abh., vol. 101, pp. 283-292, 1 pl.

Description of four *Batostomella* species, with one new subspecies, from the Permian.

FREYDANCK, H.

- 1955 - *Die Abhängigkeit einer rezenten Foraminiferen-Vergesellschaftung von Sediment und Strömungsgeschwindigkeit des Wassers*. Neues Jahrb. Geol. Pal., Abh., vol. 100, pp. 332-349, 2 pls., 3 text-figs., 4 tables.

Data sheet with fifty-seven foraminifera from the North Sea; discussion of ecologic factors.

FRICKE, K., AND THOMSON, P. W.

- 1955 - *Entstehung und Alter des Torflagers im "Seebrucher Trichter" bei Vlotho a.d. Weser*. Geol. Jahrb., vol. 70, pp. 511-514, 2 text-figs.

Pollen analysis of a Holocene peat section of 12 meters.

GANSS, O., AND SCHMIDT-THOMÉ, P.

- 1955 - *Die gefaltete Molasse am Alpenrand zwischen Bodensee und Salzach*. Deutsch. Geol. Ges., Zeitschr., vol. 105, pp. 402-495, 8 text-figs., 1 pl.

Microstratigraphic determinations and lists of foraminifera, by Knipscheer.

GEYER, O. F.

- 1955 - *Über quervergeringelte Spiculae (Silicospongia) aus dem Schwäbischen Malm*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 391-395, 2 text-figs.

Description of criomorph spicules from the upper Malm of Württemberg.

GOCHT, H.

- \*1955 - *Rhombodinium und Dracodinium, zwei neue Dinoflagellaten-Gattungen aus dem nord-deutschen Tertiär*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 84-92, 5 text-figs.

Description of *Rhombodinium draco* from the Oligocene, and of *Dracodinium solidum* from the Eocene; both n.g. et n.sp.

GÖTTLICH, K.

- 1955 - *Die Anwendung der Pollenanalyse in der Praxis des Wasserwesens*. Das Gas und Wasser, vol. 96, Ausgabe Wasser, pp. 373-375, 2 text-figs.

A pollen-diagram supports remarks on the falling of the ground-water level.

GREBE, H.

- \*1955 - *Die Mikro- und Megaflora der pliozänen Ton- und Tongyttalinse in den Kieseloolithschichten von Swisterberg/Weilerswist (Blatt Sechtem) und die Altersstellung der Ablagerung im Tertiär der Niederrheinischen Bucht*. Geol. Jahrb., vol. 70, pp. 535-574, 3 pls., 8 text-figs., 4 tables.

Diagrams, descriptions and twelve photographs of pollen and spores supplement the stratigraphy of beds overlying the Rhenanian brown coal.

GROSPIETSCH, T.

- 1954 - *Die Bedeutung der Rhizopodenanalyse für die Moorforschung*. Max Planck Ges. Göttingen, Mitt., no. 2, pp. 94-97.

Short reference to the application of rhizopods in the stratigraphy of the Quaternary.

HAGN, H.

- \*1955 - *Zur Kenntnis alpiner Eozän-Foraminiferen; III - Eorupertia cristata (Gümbel)*. Pal. Zeitschr., vol. 29, pp. 46-73, 3 pls.

Detailed description of the Eocene *Truncatulina cristata* Gümbel; suppression of *Rupertia in-crassata* Uhlig; phylogeny and distribution, with remarks on the fine structure of the wall, the canal-system, and the aperture.

- 1955 - *Zur Altersfrage der Nierentaler Schichten im Becken von Gosau*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 16-26.

Arguments (based partly on foraminifera) to the effect that the Nierentaler beds originated in the Campanian and not in the Maestrichtian.

- 1955 - *Fazies und Mikrofauna der Gesteine der Bayerischen Alpen*. Internat. Sed. Petr. Ser., Leiden, vol. 1, 174 pp., 71 pls., 8 tables.

Thin-section photographs, with short explanatory notes, of 141 samples of Triassic to Tertiary sediments of the Bavarian Alps.

- \*1955 - *Paläontologische Untersuchungen am Bohrgut der Bohrungen Ortenburg DF 1001, 1002 und 1003 in Niederbayern*. Deutsch. Geol. Ges., Zeitschr., vol. 105, pp. 324-359, 4 text-figs., 1 pl.

# HILTERMANN

A series of cores are classified, by means of foraminifera, as Santonian, Campanian, Oligocene and Miocene; description of *Asterigerina praeplanorbis* n. sp.

HAHNE, C.

1955 - *Die Tiefbohrung Senden IIa im Münsterland*. Glückauf, vol. 91, pp. 47-53.

Mention of ostracodes from the Carboniferous.

HARTUNG, W., HERBST, G., KREMP, G., AND MEYER, H.

1955 - *Die unteren Kohlscheider Schichten (mittleres Westfal A) im Horstgebiet von Erkelenz*. Geol. Jahrb., vol. 71, pp. 187-196, 1 pl., 2 text-figs.

Reference to populations of foraminifera in the correlation of coal seams.

HERBST, G.

1955 - *Die Ausbildung der Gironde-Schichten im Revier von Aachen und Erkelenz*. Geol. Jahrb., vol. 71, pp. 389-394, 1 text-fig.

Mention of populations of foraminifera and ostracodes in the productive Carboniferous.

HILTERMANN, H.

\*1955 - *Zur Artfassung in der Paläontologie*. Roemeriana, Clausthal-Zellerfeld, vol. 1, pp. 385-392.

The species is the most objective taxonomic category and the key to any system of taxonomy; examples from Recent and fossil organisms are given.

1955 - *News report - Germany*. Micropaleontology, vol. 1, no. 2, pp. 195-199.

References to various microstratigraphic meetings in 1954; 123 citations of microstratigraphic and micropaleontologic publications.

HILTERMANN, H., AND KOCH, W.

\*1955 - *Biostratigraphie der Grenzsichten Maastricht-Campan in Lüneburg und in der Bohrung Brunhilde; Teil 2 - Foraminiferen*. Geol. Jahrb., vol. 70, pp. 357-384, 3 pls., 3 text-figs., 2 tables.

Exact data on the qualitative and quantitative vertical distribution of fossils near the Campanian-Maastrichtian boundary, from two important northern German localities; besides the mollusks (determined by F. Schmid), three species of *Bolivina*, seven of *Bolivoides*, and six of *Neoflabellina* are described and figured.

HINSCH, W.

1955 - *Miozängliederung in den Erdölfeldern Heide und Bramstedt*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 349-357, 1 text-fig.

Division of the Miocene of Schleswig-Holstein into six substages, in strata penetrated by wells; stages characterised by gastropods and foraminifera.

HOFKER, H.

1955 - *Kleinforaminiferen und paläontologische Chronologie*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 77-81.

With regard to the determination of foraminifera, it is stressed that the interior characters must be considered in addition to those of the exterior.

HORST, U.

\*1955 - *Die Sporae dispersae des Namurs von West-Oberschlesien und Mährisch-Ostrau; Stratigraphischer Vergleich der beiden Gebiete an Hand der Sporen-Diagnose*. Palaeontographica, vol. 98, pt. B, pp. 137-236, 9 pls., 7 text-figs.

Description of macerations of more highly carbonized samples; establishment of a morphological system by means of the spore-formula; comparison of twenty megaspores and fifty isospores and microspores shows that most species from Upper Silesia and Mährisch-Ostrau occur in the same horizons.

JUX, U.

1955 - *Zur Geologie des Kreidegebietes von Abu Roasch bei Kairo*. Neues Jahrb. Geol. Pal., Abh., vol. 100, pp. 159-207, 2 pls., 2 text-figs., 1 table, 5 maps.

Apart from tectonic and other general data, reference is made to megafossils and to twenty-seven foraminifera and nineteen ostracodes, the determination of which is only provisional.

KLASZ, I. DE

1955 - *Zur Nomenklatur des Nordwesteuropäischen Obereozäns*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 430-435.

Compilation of stratigraphic nomenclature of the Upper Eocene, based predominantly on mollusks and nummulites.

KLINGLER, W.

\*1955 - *Mikrofaunistische und stratigraphisch-fazielle Untersuchungen im Kimmeridge und Portland des Weser-Aller-Gebietes*. Geol. Jahrb., vol. 70, pp. 167-246, 17 pls., 7 text-figs.

Stratigraphy of well sections in the basin of the Lower Saxonian Malm from the top of the Coral oolite to the serpulite, based on microfossils and Schlumberger diagrams; description

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of sixteen ostracodes of the genera *Scabriculocypris*, *Bairdia*?, *Macrodentina*, *Clithrocytheridea*, *Pleurocythere*?, *Cytherelloidea*, *Metacypris* and *Klieana*?, and the foraminiferan *Valvulina meentzeni* n.sp.; of the ostracodes, nine species are new; the vertical distributions of the foraminiferan and of thirty-five ostracodes are given; three substages each are distinguished in the Kimmeridgian and Portlandian.

KNIPSCHER, H. C. G., AND MARTIN, G. P. R.

- \*1955 - Eine neue Art der Gattung *Bolivinoidea*, *Bolivinoidea concinna* n.sp., aus dem Helvet der süd-deutschen Molasse. Geol. Jahrb., vol. 70, pp. 261-264, 1 text-fig.

Description of a new species of foraminifera from the Helvetian of southern Germany.

KOCKEL, C. W., AND TATGE, U.

- 1955 - Erster Bohrungsnachweis von Muschelkalk durch Conodonten. Erdöl und Kohle, vol. 8, p. 617.

Short reference to conodonts obtained by solution in monochloroacetic acid.

KÖWING, K.

- 1955 - Über das Alttertiär von Scheessel und Wittlohe. Naturw. Ver. Bremen, Abh., vol. 34, pp. 27-32.

Microstratigraphic determination of Oligocene clays; names of sixteen foraminifera.

KREMP, G., AND GREBE, H.

- \*1955 - Beschreibung und stratigraphischer Wert einiger Ostracodenformen aus dem Ruhrkarbon. Geol. Jahrb., vol. 71, pp. 145-170, 1 pl., 5 text-figs., 1 table.

Description and vertical ranges of Carboniferous ostracodes belonging to the genera *Carbonita*, *Whipplella* (with *Whipplella cenisa*, n.sp.) and *Jonesina*.

KRÖMMELBEIN, K.

- \*1955 - *Polyzygia gülichiana* n.n. pro *Polyzygia gülichii* Krömmelbein 1953 (*Ostracoda*). Senckenbergiana Lethaea, vol. 35, p. 371.

Renaming because of preoccupation.

- \*1955 - Arten der Gattungen *Condracypris* und *Pachydomella* im Mittel-Devon. Ibid., vol. 36, pp. 295-310, 2 pls., 3 text-figs., 1 table.

Revision and description of *Condracypris*? *circumvallata*, *Pachydomella calva*, *P. antecessens*, *P. antecessens wolfari* n.subsp., and *P. cognata* n.sp.

KRUTSCH, W.

- \*1955 - Über einige liassische "angiosperme" Sporomorphem. Geologie, vol. 4, pp. 65-76, 4 pls.

Preliminary notes and description of six sporomorphs in *Ovalipollis* and *Undulipollis*.

KÜHNE, W. G.

- \*1955 - Unterludlow-Graptolithen aus Berliner Gesteinen. Neues Jahrb. Geol. Pal., Abh., vol. 100, pp. 350-401, 18 text-figs., 1 table.

Description of graptolites from the Silurian, including thirteen species of *Monograptus*, four of which are new, and *Barrandeograptus operculatus*.

LINCK, O.

- \*1955 - Ein bemerkenswerter Seeigel-Rest (*Miocidaris pakistanensis* n.sp.) aus der Unter-Trias der Salt Range (Pakistan). Neues Jahrb. Geol. Pal., Monatshefte, pp. 489-495, 4 text-figs.

Description of a small cidarid (diameter 3 cm.) in a complete state, with corona and single spines.

LÜTTIG, G.

- \*1955 - Die Ostracoden des Interglazials von Elze. Pal. Zeitschr., vol. 29, pp. 146-169, 4 pls., 2 text-figs.

Description of ostracodes from the Pleistocene, the most complete ostracode fauna of the Pleistocene so far described; two of the twenty-seven species are new.

MÄDLER, K.

- \*1955 - Die taxonomischen Prinzipien bei der Beurteilung fossiler Charophyten. Pal. Zeitschr., vol. 29, pp. 103-108.

Division of the class Charophyta into three orders, and criticism of the morphological features used in classification.

- \*1955 - Zur Taxonomie der tertiären Charophyten. Geol. Jahrb., vol. 70, pp. 265-328, 4 pls., 3 tables.

Revision with descriptions and correlation tables containing twenty-eight Tertiary charophytes, among others *Tectochara*, *Rhabdochara* n.g., *Kosmogyr*, *Sphaerochara*, *Chara*, and *Tolypella*, with eight new species.

METZ, K.

- 1955 - Zur Paläontologie des anatolischen Paläozoikums; I - Neufunde im Paläozoikum Südwest-Anatoliens. Neues Jahrb. Geol. Pal., Abh., vol. 101, pp. 257-266, 1 text-fig.

Mention of Bryozoa and foraminifera.

NOTTMEYER, D.

- 1955 - *Stratigraphische und tektonische Untersuchungen in der rheinischen Vorbergzone bei Siebeldingen-Frankweiler*. Bad Dürkheim, Pollichia Mus., Mitt., ser. 3, vol. 2, pp. 36-93, 4 pls.

References to Tertiary foraminifera and other microfossils.

PAPP, A.

- \*1955 - *Morphologisch-genetische Untersuchungen an Foraminiferen*. Pal. Zeitschr., vol. 29, pp. 74-78, 1 text-fig.

Phylogeny of uvigerines and heterostegines from the Tertiary, and of *Pseudorbitoides* and *Lepidorbitoides* from the Upper Senonian.

POTONIÉ, R.

- 1955 - *Zur Biologie der karbonischen Sporen*. Pal. Zeitschr., vol. 29, pp. 27-32, 1 pl.

Description of ecologic functions of distinct morphological features of Carboniferous spores.

POTONIÉ, R., AND KREMP, G.

- \*1955 - *Die Spores dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte; Teil I*. Palaeontographica, vol. 98, pt. B, pp. 1-136, 16 pls., 3 text-figs., 1 table.

Detailed terminology, artificial systematics, nomenclatural separation of megaspores from isospores and microspores; 300 spores from the Carboniferous are figured and named.

RAMOVŠ, A.

- 1955 - *Die Neoschwagerinen-Schichten in den Julischen Alpen*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 455-457.

Discovery of the upper Wordian, until recently unknown in the southern Alps, with abundant brachiopods and Asiatic fusulines.

REICHELT, H.

- 1955 - *Örtliche Anhäufung mariner Fauna in dem am Niederrhein allgemein fossilfreien Horizont über Flöz Katharina auf der Zeche Friedrich Heinrich*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 185-192, 4 text-figs., 1 table.

Study of the 10 meters of beds overlying the coal seam in six localities, with brief reference to foraminifera and ostracodes.

REIN, U.

- 1955 - *Die palynologische Floez-Stratigraphie im Braunkohlen-Bergbau*. Congr. Géol. Internat., XIX (Alger, 1952), C. R., sect. 12, pp. 143-171, 32 text-figs.

Results of practical work on the stratigraphy of Tertiary brown coals from the Lower Rhine region, based on pollen diagrams and stratigraphic tables.

- 1955 - *Die pollen-stratigraphische Gliederung des Pleistozäns in Nordwest-Deutschland; 1 - Die Pollen-Stratigraphie im älteren Pleistozän*. Eiszeitalter und Gegenwart, vol. 6, pp. 16-24, 3 text-figs., 1 table.

Compilation and discussion of existing pollen diagrams and stratigraphic tables.

RUTTE, E.

- 1955 - *Problematische Mikrobestandteile aus der Oberen Süßwasser-Molasse*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 71-76, 1 pl., 1 text-fig.

Description of rounded calcitic bodies (0.1 to 0.7 mm.) of unknown origin.

SANNEMANN, D.

- \*1955 - *Beitrag zur Untergliederung des Oberdevons nach Conodonten*. Neues Jahrb. Geol. Pal., Abh., vol. 100, pp. 324-331, 1 pl., 1 text-fig., 1 table.

Vertical distribution of fourteen conodonts, and description of three new species of *Palmatolepis*.

- \*1955 - *Ordovicium und Oberdevon der bayerischen Fazies des Frankenwaldes nach Conodonten-Funden*. Ibid., vol. 102, pp. 1-36, 3 text-figs., 1 table.

Stratigraphy of the Paleozoic in the Frankenwald based on conodonts, and description of twenty-two conodonts, among them five new species.

- \*1955 - *Oberdevonische Conodonten (to II)*. Senckenbergiana Lethaea, vol. 36, pp. 123-156, 6 pls., 12 text-figs.

Descriptions of sixty-three conodonts, with two new genera and twenty new species, from the Cheiloceras stage in the Frankenwald.

SCHAUB, H.

- 1955 - *Über Sedimentations-Rhythmen in den oberen Sprockhöveler Schichten (Namur C) an Rhein und Ruhr*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 169-172, 1 text-fig.



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Short reference to foraminifera in the Carboniferous.

- 1955 - *Der Normalschnitt der Wittener (Esskohl-) Schichten am linken Niederrhein (ein Beitrag zur Flözgleichstellung Niederrhein-Ruhrgebiet)*. Geol. Jahrb., vol. 71, pp. 175-186, 1 pl., 11 text-figs.

Brief references to foraminifera and ostracodes of the Upper Carboniferous.

- 1955 - *Die Ausbildung der Girondelle-Gruppe im Niederrheingebiet*. Geol. Jahrb., vol. 71, pp. 385-388.

References to the microfauna (foraminifera, ostracodes, and others) of the Upper Carboniferous.

SCHINDEWOLF, O. H.

- 1955 - *Kleinforminiferen und paläontologische Chronologie; Einige Bemerkungen zu dem gleichnamigen Aufsatz von J. Hofker*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 82-83.

Foraminifera are said to be dependent on facies to a greater extent than cephalopods; the ranges of the Jurassic foraminifera appear to be too long for them to be as good index fossils as the megafossils.

SCHMIDT, G.

- \*1955 - *Stratigraphie und Mikrofauna des mittleren Malm im Nordwestdeutschen Bergland mit einer Kartierung am südlichen Ith*. Senckenb. Naturf. Ges., Abh., no. 491, pp. 1-76, 18 pls., 2 text-figs., 1 geol. map.

Stratigraphic revision of the most important surface exposures of the Malm in northwestern Germany, and their correlation with well sections. Descriptions of and vertical ranges of fifty ostracodes, among which are species of *Cytherella*, *Cytherelloidea*, *Limnicythere*, *Progonocythere*?, *Macrodentina*, *Clithrocytheridea*, *Haplocytheridea*, *Cyprideis*, *Protocythere*, *Exophthalmo-cythere*, *Cytheropteron*, *Orthonotacythere*, *Monoceratina*, and *Metacypris*; rare foraminifera are also described.

SCHMIDT, W. J.

- 1955 - *Der stratigraphische Wert der Serpulidae im Tertiär*. Pal. Zeitschr., vol. 29, pp. 38-45.

Vertical distribution of serpulids from the Tertiary.

SCHUBART, W.

- 1955 - *Zur Stratigraphie, Tektonik und den Lagerstätten der Witzenhäuser Grauwacke*. Hesse, Landesamt Bodenf., Abh., no. 10, pp. 19-23.

Mention of some Radiolaria.

SDZUY, K.

- \*1955 - *Cystoiden aus den Leimitz-Schiefen (Tremadoc)*. Senckenbergiana Lethaea, vol. 35, pp. 269-276, 1 pl., 5 text-figs.

Revision and detailed illustration of *Macrocystella? bavarica*, and description of *Calix? dorecki*, n.sp.; determination of isolated single parts of these Silurian fossils is possible.

SEIBOLD, E., AND SEIBOLD, I.

- \*1955 - *Revision der Foraminiferen-Bearbeitung C. W. Gümbels (1862) aus den Streitberger Schwamm-Mergeln (Oberfranken, Unterer Malm)*. Neues Jahrb. Geol. Pal., Abh., vol. 101, pp. 91-134, 2 pls., 5 text-figs.

Revision of twenty-eight Malm foraminifera published in 1862 by Gümbel; description of neotypes.

SEITZ, O.

- 1955 - *Das Ergebnis von vier Tiefbohrungen im Felde Bismarck bei Liebenburg über Goslar*. Roemeriana, Clausthal-Zellerfeld, vol. 1, pp. 289-298, 3 text-figs.

Microstratigraphic determination of the lower Albian and the boundary between the Rhaetic and Liassic.

SIEVERTS-DORECK, H.

- 1955 - *Die Verbreitung der Crinoiden-Gattung Saccoma im Schwäbischen Jura*. Ver. Vaterl. Naturk. Württemberg, Jahreshefte, vol. 110, pp. 118-120.

Malm crinoids found by K. Feifel in washed residues from fifteen localities.

THOMSON, P. W.

- 1955 - *Zur Frage des Alters des Braunkohlenlagers vom Roten Kliff auf der Insel Sylt*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 69-70, 1 table.

Table with 200 species of tree pollen from the Upper Pliocene.

VOIGT, E.

- 1955 - *Artspezifischer Parachronismus(?) von Serpuliden in Kreide-Bryozoen*. Pal. Zeitschr., vol. 29, pp. 8-20, 2 pls.

# HILTERMANN

*Onychocella* species from Maestrichtian tuff contain in their zooecia very minute specimens of *Serpula obliqua*, considered to be symbionts.

WEILER, W.

1955 - *Nachträge zu W. Weiler "Otolithen" 1954*. Senckenbergiana Lethaea, vol. 35, pp. 367-368.

Rectification of some statements concerning Mesozoic fish otoliths published by Martin and Weiler in 1954.

\*1955 - *Untersuchungen an der Fischfauna von Unter- und Oberkirchberg bei Ulm, vornehmlich an Hand von Otolithen in situ*. Pal. Zeitschr., vol. 29, pp. 88-102, 1 pl., 1 text-fig.

Revision and description of five otolith species from the Helvetian, based on well-preserved specimens.

WETZEL, W.

\*1955 - *Die Dan-Scholle vom Katharinenhof (Fehmarn) und ihr Gehalt an Planktonen*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 30-46, 27 text-figs.

Twenty-one forms of *Hystrichosphaera*, *Hystrichosphaeridium* (with two new subspecies), *Microhystridium*, *Palaeoperidinium*, and *Pterospermopsis* were obtained from 10 grams of flint.

WEYL, R., REIN, U., AND TEICHMÜLLER, M.

1955 - *Das Alter des Sylter Kaolinsandes*. Eiszeitalter und Gegenwart, vol. 6, pp. 5-15, 2 text-figs.

Pollen-stratigraphic study of two newly exposed brown-coal deposits indicates an Upper Pliocene origin.

WICHER, C. A.

1955 - (Mikrostratigraphische Untersuchungen.) In: SCHNEIDER, O., *Das Senkungsfeld von Laub, ein Beitrag zur Geologie der Gegend von Regensburg*. Acta Albertina Ratisbonensia, Regensburg, vol. 21, pp. 6-8.

Age and foraminifera of some samples from the Upper Cretaceous.

WOPFNER, H.

1954 - *Neue Beiträge zur Geologie der Gosauschichten des Muttekopf-Gebietes (Tirol)*. Neues Jahrb. Geol. Pal., Abh., vol. 100, pp. 11-82, 4 pls., 19 text-figs., 1 map.

Reference to foraminifera of the Upper Cretaceous *Orbitoides-Lithothamnion* sandstones.

ZEIL, W.

1955 - *Die Kreide-Transgression in den Bayerischen Kalkalpen zwischen Iller und Traun*. Neues Jahrb. Geol. Pal., Abh., vol. 101, pp. 141-226, 9 pls., 14 text-figs.

Reference to microstratigraphic determinations in the Upper Cretaceous.

ZÖBELEIN, H. K.

1955 - *Über Alttertiär-Gerölle aus der subalpinen Molasse des westlichen Oberbayerns und der inneralpinen Molasse (Angerbergsschichten) des Tiroler Innlandes*. Neues Jahrb. Geol. Pal., Monatshefte, pp. 342-348.

Paleogeographic evaluation of thin sections of Lower Tertiary boulders; micropaleontologic classification by Reichel.

## Systematic methods for Paleozoic plant microfossils\*

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[EDITORS' NOTE: The following two notes are condensations of the second and third of ten papers presented at a round-table program on plant-microfossil systematic methods to which the Paleobotanical Section of the Botanical Society of America devoted one day of its annual meeting at East Lansing, Michigan, in September, 1955. Other papers presented at this round-table program will be published in future numbers of this quarterly.]

This paper deals primarily with methods of systematics employed by German, French, and Dutch workers. However, some contributions pertinent to the development of systematic methods regardless of national origin are included in order to give continuity to the discussion. In this paper the term "microfossil" is interpreted to mean a plant spore or spore-like body. A review of the different systems of classification discloses a progression, although not necessarily unilateral, from the simple, purely practical to a highly evolved system of nomenclature.

Reinsch's monumental work (1884) failed to gain universal recognition because of gross misinterpretations. His drawings, however, are well done and usable in comparative studies. He established the following plant microfossil tribes: *Trileteae*, *Stelideae*, *Discieae*, *Rhizostamideae*, *Sphaerocladitae*, *Leptoideae*, *Plegmiteae*, *Dictophiteae*, *Stolidermeae*, and two unnamed tribes. His tribes were divided into subtribes, which in turn consisted of subdivisions. The tribe *Trileteae*, for example, was divided into four subtribes, which had a total of 111 subdivisions. Distinct types (species?) were numbered consecutively. Thus, the tribe *Trileteae* contained 631 "types." The tribe *Stelideae*, defined by Reinsch as noncellular thalli of definite and constant

shape and as being parasitic upon organic bodies, was divided into two subtribes, *Trichostelium* and *Stichostelium*. Bennie and Kidston (1886) recognized Reinsch's *Stelideae* as flanges of "macrospores" and consequently transferred them to the *Triletes* tribe. Because these authors used the term "Triletes" and numbers to designate their different kinds of spores, it is assumed that they intended "Triletes" to be a generic designation. A second "genus," *Lagenicula*, was established by these authors in order to accommodate two "species." Bennie and Kidston divided *Triletes* into *Laevigati*, *Apiculati*, and *Zonales* and listed eighteen species under these three headings.

Lange (1927), investigating spores from the Upper Silesian basin, duplicated Bennie and Kidston's system. Flangeless spores became "Alpha-Sporen" instead of *Laevigati*, flanged spores became "Beta-Sporen" instead of *Zonales*, and Bennie and Kidston's *Apiculati* were called "Knoten-Sporen." Within these groups, Lange differentiated "types" on the basis of wall thickness. Potonié (1927) pointed out the need for classifying and cataloguing all spores and suggested that the word "Sporonites" be appended to all generic fossil spore names to differentiate spores from other plant fossils.

After Bartlett (1928) had reduced Reinsch's *Triletes* to generic rank and applied the binomial system to spores of that genus, Zerndt (1930a), apparently unaware of the systematic progress that had been made, classified megaspores according to size, referring to spores as follows: "Spore 0.6 mm.," "Spore 2.1 mm.," etc. In a subsequent report, Zerndt (1930b) adopted Bennie and Kidston's system with slight modification, that is, reducing *Lagenicula* to subgeneric rank under *Triletes*, and used binomial designations for several of the new species he described. In another report, Zerndt (1931) adopted a numerical system that estab-

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lished types 1 to 31 and relegated Kidston's types, as well as his own previously established binomials, to synonymy. He removed the *Lagenicula* group from *Triletes*, but did not refer to it as a "genus." Stach and Zerndt (1931) changed "type" to "form" and unwisely failed to retain the same numbers. For example, "Type 3" became "Form 1" and "Type 9" was changed to "Form 2". Maslankiewiczowa (1932) eliminated the "type" and "form" designations and substituted a binomial system. She also returned *Lagenicula* to group status under *Triletes*.

Potonié, Ibrahim, and Loose (1932) divided the spores found in Ruhr coal seams into microspores and megaspores, but they ignored Potonié's suggestion of compounding generic names by fusing a descriptive word with the suffix "sporonites"; instead they used "sporonites" singly as a universal generic name. Ibrahim (1933) shortened this name to "Sporites" and raised it to higher taxonomic rank, as well as using it as a generic suffix as Potonié had proposed. The group *Sporites* was divided into *Triletes*, *Monoletes*, and *Aletes*. Affiliation of spores with these subgroups was indicated by different vowels terminating the descriptive part of the generic term. If a spore belonged to *Triletes*, the descriptive word ended in "i"; if to *Monoletes*, in "o"; and if to *Aletes*, in "a." Ibrahim's system is reproduced below:

Zerndt (1934) ignored the Potonié school as well as his own student, Maslankiewiczowa; he returned to type designations and numbers (after he and Stach had changed to "form") and added letters to designate varieties. Any previously established binomials were listed after the numbered type. In a later paper, Zerndt (1937) actually established varieties by using trinomials. For example, *Type IIa* became *Triletes auritus* var. *grandis* Zerndt. By resurrecting *Lagenicula* and giving it generic rank, Zerndt dealt with two genera, *Triletes* and *Lagenicula*. The former he kept divided into the three subgeneric divisions established by Bennie and Kidston.

Sahabi (1936) also retained Bennie and Kidston's three divisions of *Triletes*, which he called groups. In addition, he divided the *Zonales* into subgroups *Exosporonales* and *Perisporonales* and the *Apiculati* into *Zonaloapiculati* and *Euapiculati*. He did not use binomials, however, but designated "species" by Roman numerals and used "type" as the generic name. Dijkstra (1946), in his megaspore monograph, followed Schopf's (1938) system of dividing *Triletes* into sections; he retained *Aphanozonati*, *Lagenicula*, and *Triangulati* but replaced section *Auriculati* with *Zonales*. Dijkstra separated two extremely large microspores from *Triletes*, where Zerndt had placed them, and established the genus *Microsporites* to accommo-

## SPORITES H. Potonié 1893

## A. TRILETES Reinsch 1881

- I. *Laevigati-sporites*
- II. *Punctati-sporites*
- III. *Granulati-sporites*
- IV. *Tuberculati-sporites*
- V. *Apiculati-sporites*
- VI. *Verrucosi-sporites*
- VII. *Setosi-sporites*
- VIII. *Zonales-sporites*
- IX. *Alati-sporites*
- X. *Valvisi-sporites*
- XI. *Reticulati-sporites*

## B. ALETES Ibrahim 1933

- I. *Punctata-sporites*
- II. *Apiculata-sporites*
- III. *Zonala-sporites*
- IV. *Reticulata-sporites*

## C. MONOLETES Ibrahim 1933

- I. *Laevigato-sporites*
- II. *Punctato-sporites*
- III. *Zonalo-sporites*

Wicher (1934) eliminated Ibrahim's *Aletes* group and listed microspores separately; thus all megaspores were left in the two remaining groups, *Triletes* and *Monoletes*. He elevated six of Ibrahim's generic names to suprageneric rank and applied the standard generic designation "sporites" to all spores. *Sporites glabratus*, for example, belonged to the *Laevigati-sporites* group of *Triletes*, and *Sporites silvanus* to the *Zonales-sporites* of the *Triletes*.

date them. Erdtman (1947), in his attempt to systematize all fossil and Recent pollen grains and spores, established thirteen coenotypes. Of interest is his division of "laesurate" spores. Monolete iso- and microspores would be called *Monolites*, whereas megaspores with a single scar would be termed *Monoletes*. Trilete iso- and microspores would be grouped under *Trilites* and trilete megaspores under *Triletes*. Kalibová (1951) apparently followed Schopf, Wilson and Bentall's



# SYSTEMATICS OF PALEOZOIC PLANT MICROFOSSILS

(1944) system. She listed megaspores under three genera, *Triletes*, *Cystosporites*, and *Monoletes*, and "microspores" as *Cirratiradites* and *Calamospora*.

Potonié and Kremp (1954) established a rather elaborate framework for classifying Paleozoic spores. Without doubt, this work is the most definitive and comprehensive to date and is a major contribution to palynologic systematics. The elimination of cumbersome hyphenated generic terms propagated by Potonié's former students is commendable, and the legitimization of genera by genotypes adds strength to the system of spore classification. These authors group all spores and spore-like propagules into three "Oberabteilungen": the *Sporonites*, the *Sporites*, and the *Pollenites*. *Sporites*, for example, is divided into four "Abteilungen": the *Triletes*, the *Zonales*, the *Monoletes*, and the *Cystites*. "Abteilung" *Triletes*, in turn, consists of two "Unterabteilungen": the *Azonotriletes* and the *Lagenotriletes*. "Unterabteilungen" are further divided into "Reihen," which in turn include the genera. With the addition of specific and varietal entities, this system would comprise seven echelons. Whether this elaborate system can stand the test of practicality, that is, be useful in keying out individual spores, must still be proved. Palynologists cannot afford to ignore the great challenge which stratigraphic correlation represents, and must therefore be ever mindful of the usability of their systems of classification and nomenclature.

Standardization is needed. The quality of illustrations has shown great variability. Many line drawings prove useless in comparative studies, as do some of the poorly reproduced photomicrographs. A policy regarding the designation of types and depositories needs to be established, and the relative magnitudes of generic and specific characteristics need to be defined.

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TABLE I

SUMMARY OF SYSTEMATIC METHODS USED FOR MESO-CENOZOIC POLLEN AND SPORES BY JAPANESE, INDIAN, NEW ZEALAND AND AUSTRALIAN PALYNOLOGISTS

PALYNOLOGISTS	METHODS OF PREPARATION	METHODS OF ILLUSTRATION	METHODS OF DESCRIPTION	TYPES: DESIGNATION AND DEPOSITION	SYSTEMATIC NOMENCLATURE EMPLOYED
Japan: Shimada Nakamura	Lignites boiled in 10% KOH, mounted in glycerin (Shimada), otherwise very scanty data.	Tables and diagrams of frequency of occurrence used. No illustrations of microfossils published.	Microfossils not described except for identification or comparison with Recent genera or families.	No types designated, as species not described. No specific preparations referred to.	Microfossils referred to Recent taxa or compared with Recent taxa, mostly to genera, in a few instances to a family, e.g.: <i>Liriodendron</i> <i>Sequoia</i> type Ericaceae.
India: Sen Rao and Vimal	Sen: Coal macerated with Schultze's solution, neutralized with 10% KOH, mounted in glycerin jelly or Canada balsam. Rao and Vimal: Lignites heated, macerated 1 wk. in conc. HNO <sub>3</sub> , 2 hrs. in 10% KOH, mounted in glycerin jelly; no staining.	Sen: Simple, semi-diagrammatic line drawings. Magnification not listed. Rao and Vimal: Stippled line drawings, partly camera lucida, partly semi-diagrammatic, and photomicrographs. <i>Magnifications</i> : 566, 587, 650, 670, 675, 700, 740, 1200, 1280, 1300.	Sen: Exine characters, apertures, other features described briefly. Terms popular or from Erdtman. Size given. Rao and Vimal: Exine characters, apertures, markings, shape, described briefly in popular terms or terms from Erdtman. Size given.	Sen: No types designated, no specific preparations referred to. Rao and Vimal: No types designated, as species not described. Vimal (1952) designated specific slides (e.g., "Slide No. S.R. 2"), not locations on slides. Deposition of slides not given.	Sen: Groups (Roman numerals) comparable with genera, and types (letters) comparable with species, e.g.: IV, type H. Rao and Vimal: Purely morphologic groups comparable with genera, and types comparable with species; the types are given numbers; type groups for the most part from G. Erdtman; e.g.: <i>Aporosa</i> type No. 11.
Australia: Cookson and coworkers	Lignites treated by chlorination and acetylation; residue washed in 5-10% warm KOH and mounted in fuchsin or safranin-stained glycerin jelly. Sediments with high mineral content treated with HF before chlorination. Maceration in Schultze's solution sometimes substituted for chlorination-acetylation.	Photomicrographs only. <i>Magnifications</i> : 500, 600, 620, 625, 630, 800.	Rather briefly described in important features, using Erdtman terminology. Size given.	Type specimens not designated. Illustrations not referred to specific preparations or slides. No deposition for specimens given.	Essentially as for Couper (below) except that Cookson regards her "genera" and "species" as sporotypes and sporomorphs, not governed by normal systematic rules. She does not designate types; e.g.: 1. <i>Gleichenia circinidites</i> 2. <i>Myrtacoidites eugenioides</i> 3. <i>Triorites thomasi</i> 4. <i>Nothofagus</i> sp. Compare with listings under Couper for types of names as indicated by numbers.
New Zealand: Couper and coworkers	KClO <sub>4</sub> - HNO <sub>3</sub> maceration (Schultze's solution) for most preparations; boiling in 10% KOH for some low-rank lignites; residue stained with fuchsin and mounted in glycerin jelly. Acetylation not used because of swelling effect.	Mostly stippled drawings, some photomicrographs. <i>Magnifications</i> : 667, 1334 (drawings); 1000, 1040, 1060, 1070, 1080, 1130, 1140, 1200, 1280 (photomicrographs).	Briefly described for all principal features, using Erdtman terminology when new species are described. Otherwise refers to other published descriptions. Size given.	A type specimen designated for each new species. Reference made to a specific preparation and slide, deposited at N.Z. Geol. Survey.	Properly designated generic and specific names are used, the genera being either: 1) Recent genera, or names of the sort suggested by Erdtman as: 2) <i>nomina typica concreta</i> or 3) <i>nomina typica abstracta</i> ; e.g.: 1. <i>Dacrydium microscacatum</i> 2. <i>Podocarpidites marwickii</i> 3. <i>Perotrilletes granulatus</i> . In other instances, a fossil is merely referred to the smallest possible Recent taxon, e.g.: 4. <i>Plantago</i> sp.

# Systematic methods for Mesozoic and Cenozoic plant microfossils

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This report outlines in brief the systematic methods, primarily the systematic nomenclature, used for Mesozoic and Cenozoic pollen and spores by palynologists in Australia, India, Japan, New Zealand, and the Soviet Union. Table 1 gives the information covered in tabular form.

Shimada and Nakamura, Japanese investigators, have published on late Tertiary sediments, using essentially the same systematic techniques as do Pleistocene palynologists. They have referred plant microfossils to taxonomic units of Recent plants, and have not developed a systematic nomenclature for fossils as such.

Rao and Vimal, Indian palynologists, have put Mesozoic and Cenozoic microfossils in purely morphologic classes and types, in some instances within the morphologic classes of Erdtman. They have emphasized the difficulties of identification with Recent taxonomic units, but probably err in feeling that valid binomial nomenclature for plant microfossils must wait until supporting megafossil evidence is available and until Recent forms are more fully known. Names used by Rao and Vimal, such as "Aporosa type 11," are, in a sense, binomial, but have the serious defect of being invalid. As the International Code of Botanical Nomenclature adopted by the Seventh International Botanical Congress (1950) states (Article 9, p. 14): "The purpose of giving a name to a taxon is not to indicate its characters or history, but to supply a means of referring to it."

Cookson, the principal Australian scientist in this field, uses a sporotype-sporomorph system modified from suggestions of Erdtman. Sporotypes are treated as of the same rank as genera, sporomorphs are comparable to species. In some instances, she has put fossil pollen

in genera of Recent plants. Presumably because she has regarded the sporotype-sporomorph system as outside the normal paleontological systematics, she has not designated types. The New Zealand palynologist Couper uses a system similar to Cookson's, but describes his units as genera and species, with careful designation of types and explicit descriptions. Couper has considered it necessary to validate Cookson's sporotypes and sporomorphs as genera and species in his publications.

Unfortunately, information on the activities of the seventy palynologic laboratories in the Soviet Union is as yet too scanty to permit a general statement on their systematic techniques, although Kouprianova, a leading Soviet palynologist, has stated that a "natural" system is used for post-Paleozoic microfossils.

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# notes and comment

## A technique for the preparation of multi-grain palynological slides

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Since workers in palynology use the type-specimen method in establishing new genera and species, single-grain preparations are more desirable than strew-slide preparations. Such slides are easily handled and contain no detritus to interfere with observation. Single-grain preparations consist of clean spores. Nevertheless, single-grain preparations have their disadvantages when the pollen analyst wants to compare a number of specimens from the same sample. In these circumstances, single-grain preparations make it necessary to use a considerable number of slides, which occupy too much space in the collection. Furthermore, much time is required in repeatedly changing and adjusting the slides under the microscope, which is particularly inconvenient when making photographs. For these reasons, a multi-grain slide mount arranged in the form of a checkerboard has been developed. Such a slide furnishes sufficient space for 100 objects. Each area is marked by letters and figures to permit indexing of the specimens. Because of this arrangement, a calibrated microscope stage is unnecessary. However, the development of this type of multi-grain slide was not possible until the methods of Erdtman (1943), Faegri (1936), and Klaus (1953) for preparing single-grain slides had been somewhat simplified.

### SINGLE-GRAIN PREPARATIONS

The prepared palynological residue is mixed with glycerin, and one drop is transferred to a glass microscope-slide and dispersed. The slide is then placed on a white sheet of paper and examined under a binocular microscope at a magnification of 100 $\times$ , by reflected

light. With a very thin needle mounted in a convenient handle, objects can be picked up from the drop. Two methods may be employed: Either the needle is placed underneath the spore, and the spore is then lifted out of the liquid, or the needle is used to push the spore out of the drop. The spore is then moved from side to side until it is almost dry, when it can then be picked up with the side of the needle. For the handling of very minute and fragile objects, the instruments described by Klaus (1953) are recommended.

Before transferring the isolated specimen to its permanent mount, the latter is prepared in the following manner: A minute drop of hot glycerin-gelatin is placed on another slide with the aid of a thin wire hook. This slide is then placed parallel to the slide containing the raw material. With the isolated spore sticking to the needle, the second slide is pushed into the field of view until the analyst is able to see the convex drop of glycerin-gelatin. The needle and spore are immersed in the liquid and the needle is moved to and fro until the spore floats free. The drop is then dispersed in all directions with the needle, with the spore kept in constant view, until the drop has been reduced to a thin film. Any foreign matter can be removed from the spore during this process, so that it is left entirely clean on the slide. Flat spores will automatically assume a flat position, but others can be oriented in any desired position. Manipulation must be completed quickly, however, before the glycerin-gelatin becomes too viscous. It has been possible to transfer spores as small as 20 $\mu$  in diameter by the method just described.

The isolated spore must be fixed in place to prevent it from moving in the preparation when the cover-glass is put in place. To accomplish this, the slide is placed on a hot-plate until the thin layer of glycerin-gelatin enclosing the spore has become dry. However, the heating must not be continued too long, or the spore and the embedding medium will turn brown. The analyst must note when the thin layer of liquid begins to shrink, and must turn off the heat at that point. It is of no consequence if a small residue of the liquid remains after the plate has cooled down somewhat, for the water and a part of the glycerin will evaporate. The slide is removed from the hot-plate and allowed to cool completely. At this stage, any liquid still remaining has become so viscous that the spore can be covered with a drop of warm glycerin-gelatin and a cover-glass can be placed over it without dislodging it from its position. A whole series of slides can be prepared beforehand and dried simultaneously on the hot-plate. In practice, the container of glycerin-gelatin is warmed on the same plate, so that the plate is already heated before the slides are prepared. In setting the cover-glass in place, only sufficient liquid to spread to the edge of the cover-glass is used. It is not necessary to weight the cover-glass, because the thin layer of embedding medium will hold it fast. If too much liquid was used, the cover-glass can be pressed down lightly, causing the surplus glycerin-gelatin to flow out from beneath it. After one or two days, the slides can be washed free of gelatin with running water and light rubbing with the finger. Slides should eventually be sealed with balsam or varnish to prevent deterioration.

The method described may be modified to conform to individual preference. For example, two cover-glasses of different sizes attached to a piece of cardboard can be used instead of the slide recommended by Klaus. Spore position may be marked on the slide according to the method described by Klaus; or, under the microscope, dots of India ink can be placed on the cover-glass alongside of the spore. Some analysts prefer to cement an arrow-shaped piece of paper to the cover-glass to indicate the position of the spore. If the surface-tension of the glycerin drop containing the raw material is too great, it can be reduced by adding a drop of liquid glycerin-gelatin. Preparations with a thin gelatin layer will keep, even without sealing, for many years if they are stored in a dry place. Many other variations of these methods can be employed.

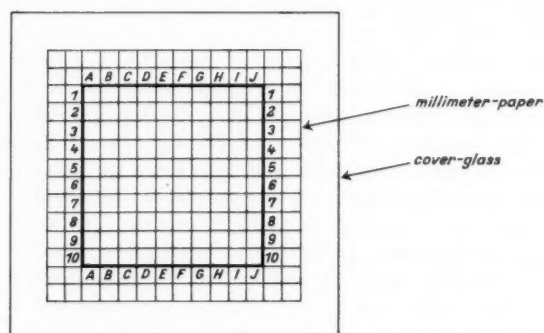
The method described above may appear to be more complicated than it really is, but there are actually only five different steps to be carried out, as shown in

the following summary (if staining is desired, the entire raw material can be stained in the centrifuge tube, and the surplus stain washed out by repeated centrifuging):

- 1) Disperse a drop of prepared material in glycerin on a glass slide.
- 2) Transfer a very small drop of hot glycerin-gelatin onto a second slide.
- 3) Place both slides on a white paper under the binocular microscope. Isolate a single spore from the dispersion with a needle and transfer it to the minute drop on the second slide. The drop is then spread flat with the needle.
- 4) Dry the thin glycerin-gelatin layer on the hot-plate.
- 5) Add a drop of warm glycerin-gelatin to the preparation and cover with a cover-glass. After the slide has cooled, labelling, marking, and sealing are carried out by the methods that are customary in making other microscopic preparations.

#### MULTI-GRAIN PREPARATIONS

In the same manner, several grains can be combined in one preparation. If almost identical spores are placed side by side, they can be studied in various positions or in different states of preservation without the necessity of changing slides. In addition, analysts have often wished (for example, in the case of poor or strongly contaminated samples) to be able to isolate the spores like other microfossils. This may be accomplished in the following manner: A frame one centimeter square is outlined in black India ink on



TEXT-FIGURE 1

transparent millimeter-paper with dark printing (blue or black), and the individual rows are designated along the edges by means of very small figures and letters, as in a chess problem (text-fig. 1). The square

figure is then cut out and attached, printed side up, with transparent gum, in the center of the underside of a microscope slide. After the gum dries, the back of the paper is rubbed with a small drop of oil or liquid paraffin, in order to make the paper even more transparent. It would be ideal if the millimeter network could be etched on the glass. However, the transparent millimeter-paper is satisfactory; with a strong microscopic lamp, the decrease in the intensity of the light is hardly noticeable.

The upper side of the microscope slide is then covered, line by line, with a thin film of hot glycerin-gelatin, and the spores are placed in the squares. The slide is then completely dried on a hot-plate, and an 18 × 18 mm. cover-glass is placed on the mount as described in the single-grain technique. During the drying process, care must be taken to ascertain that the spores are not dislodged, or, if they are, to replace them in their original positions. Whether or not a spore is set in each of the 100 square millimeters depends upon the abundance of the spores in the sample or upon the reasons for selecting them. In this manner, the analyst should be able to attain the goal of being able to isolate the spores, at least from one drop of raw material, as easily as can be done with other microfossils.

Multi-grain slides may be used in various ways. The spore flora of a single locality can be represented neatly on one slide. Preparations for teaching or exhibition purposes can be made; spores showing various

states of preservation can be selected; or a morphogenetic series can be constructed. It is furthermore recommended that a list of the spores on each slide be kept, with their locations indicated by letter and number. An enlarged drawing of the grid can also be made, in which the spores are sketched according to their position. The multi-grain slide can serve in the same way in palynology as the Franke cell does in other fields of micropaleontology. Such preparations can be made by relatively unskilled workers. Multi-grain slides also serve to speed up photographic work. Paratypes and hypotypes can be stored with security in this manner. Single-grain preparations need not be made for them, and much space can be saved.

It must be stated, however, that the strew-slide cannot be dispensed with in counting spores, and the single-grain preparation will always serve best for the purpose of typification. Nevertheless, in many other ways, the multi-grain preparation is definitely more useful.

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## Preparation of microfossils for photography

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The preparation of microfossils for photography usually includes the coating of specimens by chemical methods. By reducing the natural shine and enhancing morphological detail, such a coating ensures the best results. Numerous coating techniques have been described, including the use of ammonium chloride as a whitening agent and the application of carbon as a method of darkening the specimen.

There are two major disadvantages, however, in the majority of techniques in common usage. The granularity of the chemical coating may be of the same dimensions as some of the finer morphological detail, and hence mask this detail. This is especially true in the case of smaller microfossils, when ammonium chloride has been used as a whitening agent. Secondly, many techniques make it impossible to remove the individual specimens from their mounted positions without destroying part of the chemical coating.

During a revision of the Upper Palaeozoic smaller foraminifera, a very simple method of darkening specimens was developed that overcomes both these difficulties. Furthermore, the whole procedure can be carried out under continuous observation on the microscope stage, and hence the exact degree of coating can be ensured at all points. The method is as follows:

- 1) After removal of all dirt and loose fragments by washing in water with a camel-hair brush, the specimen is placed in an ordinary cardboard slide.
- 2) The specimen is then brush-washed with a 10 per cent solution of silver nitrate and allowed to remain in this solution for a variable period, up to five minutes. Excess liquid is removed by repeated application of a dry brush around the margins of the specimen, and the latter is then permitted to dry.
- 3) The dried specimen is brush-washed with ordinary photographic developer and allowed to soak in the excess liquid for one or two minutes. The excess is then removed and the specimen dried. The intensity of darkening can be increased by repeated applications of developer.

The net result of this technique is that the specimen becomes covered with an extremely thin dark coating. This is sufficiently strong to withstand the effects of gentle handling, and hence the darkened specimen can be mounted on a clean white background in the required position for photography. After the preparation of illustrations, the coating can be removed from the specimen by washing rather vigorously in warm water, with a brush.

## The Paleontological Society of the Argentine

ESTEBAN BOLTOVSKOY

*Museo Argentino de Ciencias Naturales  
Buenos Aires*

Argentine paleontology is rich in fine old traditions. Alcide d'Orbigny, the great student of foraminifera and one of the founders of micropaleontology, published epoch-making works on foraminifera in the first half of the Nineteenth Century. The main part of the material studied by him in one of his major works was collected in the Argentine epicontinental sea. In the second half of the same century, a famous Argentine scientist, F. Ameghino, worked on the vertebrate fossils of his native land. There have been many other investigators, both native and foreign, who have also made valuable contributions to the study of various fossil animal and plant groups.

A group of Argentine paleontologists, continuing the traditions of the past, recently decided to organize the Paleontological Society of the Argentine. A provisional Executive Committee was appointed at their first meeting, which was held late in 1955. This Committee will do all the preliminary work until regular officers are chosen for the National Assembly. Professor A. F. Leanza of the University of Buenos Aires was elected President of this Provisional Committee.

The principal aims of the Paleontological Society are to promote the paleontological sciences; to establish better liaison between all provincial geological and paleontological museums and institutions and to assist them in every way possible; to organize paleontological

conferences and expeditions; and to make arrangements for fellowships for students working in paleontology. Furthermore, the Society will strive to extend contacts between Argentine paleontologists and their colleagues abroad, and to organize the international exchange of paleontological material and collections. In order to better realize these aims, a journal, to be known as "Ameghiniana," is being established.

All friends of paleontology and allied sciences, regardless of their nationality, location or scientific title, are eligible for membership in the Society. The fee is six dollars per annum for individuals, and ten dollars per annum for institutions and societies. All members receive the journal free of charge. "Ameghiniana" will be devoted to all types of subjects connected with paleontology in general, from micropaleontology to vertebrate paleontology. This journal will be a quarterly; it will be illustrated; all articles will have summaries either in English (mainly) or in German and French. The first number will contain ten papers, and is to be published shortly.

The Paleontological Society of the Argentine invites all specialists, as well as all friends of paleontology, to contribute papers to "Ameghiniana" and to join the Society. Correspondence should be directed to O. A. Reig, the Secretary of the Society, Angel Gallardo 470, Buenos Aires, Argentina.



## Suggestions to authors

Manuscripts of all papers *other than news items*, submitted for publication in "Micropaleontology," should be sent to the Department of Micropaleontology, American Museum of Natural History, Central Park West at 79th Street, New York 24, New York. *News items*, however, should be sent to the correspondent reporting for the contributor's area.

Much unnecessary work and expense can be avoided if a standardized procedure is followed in the preparation of manuscripts. With this in mind, the following suggestions are offered to authors.

### COPIES

One original and one carbon of the text and figure explanations should be submitted. Duplicate illustrations are not required.

### PAPER

Articles submitted for publication in "Micropaleontology" are to be typed on opaque, white, heavy-weight paper not less than 8 × 10 nor more than 8½ × 11 inches in size. The use of onion-skin or legal-size paper introduces difficulties for the editors and printers in reading and handling.

### SPACING

All text, with no exceptions, is to be typed double-spaced. This rule includes the bibliography, the abstract, synonymies, quotations, tables, explanations of figures, etc. Standard-size (pica) type is preferable to small (elite) type.

### ABSTRACT

All papers are to be accompanied by an abstract. It should be about 60 to 70 words in length, and is to be in English regardless of the language employed in the paper itself.

### TITLE AND SUBJECT HEADINGS

The title of the paper should be not more than 75 characters in length, including spaces. Subject headings should be limited to about 45 characters. The title and headings of sections are to be typed in capital letters, without underlining.

### ITALICS

In general, nothing is to be underlined for italics except the Latin names of genera and lower taxa when they occur in the running text or in the synonymy. No names are to be underlined in the systematic headings. Occasionally, a word or sentence in the text can be set in italics for special emphasis.

### SYSTEMATIC HEADINGS

Inasmuch as this quarterly covers the entire field of micropaleontology, it is desirable to furnish a complete classification for the group or groups of organisms under discussion in the systematic section. Give the name of the phylum, class, order, family, genus and subgenus (if any), each preceded by the appropriate word. Other intermediate categories may also be given if desired. Be sure to verify the spelling, as the editors cannot do so for all groups of micro-organisms. Names of genera and subgenera are to be accompanied by author and date, for whose accuracy the contributor must be responsible. Omit the date in headings for species and lower taxa.

### ELIMINATION OF FOOTNOTES

No footnotes are to be used. "Permission to publish" can be included under acknowledgments. Explanatory or tangential remarks should be incorporated in the text. If they are too irrelevant to be incorporated, they can probably be omitted without harm. The depository of types and other specimens can be cited in the introductory portion of the paper.

### SYNONYMY

The form to be used for synonymy can be seen by examining papers printed in this quarterly. Note that the author of the systematic name is carried with each subsequent reference and is typed lower-case, whereas the author of the particular reference cited is typed in capital letters. In the reference in which a scientific name was first published as new, the author's name is typed in capital letters and is not repeated.

### REFERENCES

Bibliographic references are to be identified in the text by giving the author and date of publication, with a page number if desired, and cited in full in the bibliography at the end of the paper. They should not be

indicated as footnotes. Abbreviated references are to be used in synonymies.

#### STYLE AND LANGUAGE

Parenthetical remarks and long, involved sentences should be avoided. This is an international publication, and not everyone can follow a highly complicated style in a language other than his own. Relatively short paragraphs are also desirable.

Papers will be accepted for publication in any language that employs Latin characters. The editors and printers will do their utmost to reproduce all diacritical marks, but in some cases it may not be possible to do so. The abstract, as indicated previously, is to be in English regardless of the language employed in the text.

#### BIBLIOGRAPHY

The general form of the bibliography can be seen by examining papers already printed in this journal. The actual date of issue of the paper cited should be given as the date of publication below the author's name. Please note that many publications issued in parts do not always bear the same date as the year covered by the whole volume. Good examples of this point are the "Eclogae," of which Number 2 of each volume is always issued during the year following that of Number 1, and the Bulletins of the Geological Society of France, of which parts of each volume are issued during two or more years.

Note also that the titles of articles or books are to be underlined for italics, with nothing capitalized except proper nouns. The title ends with a period. For books, the place of publication follows the title, and is followed by a colon. After the colon, give the publisher, the volume number (if any), and the pagination. For serial publications, the word order and abbreviations to be used are shown in the "List of Publications" and "List of Abbreviations" issued as part of Volume 30 of the Catalogue of Foraminifera. The place of publication is to be omitted in citations of serial publications, except in cases of ambiguity or obscurity. Series,

volume, and number or part are to be given, with their appropriate abbreviations. Complete pagination, plates and figures for the article cited should be given whenever possible.

#### ILLUSTRATIONS

All plates are to have a white background. The finished size of the plates will be  $7 \times 9$  inches exclusive of margins. Original plates should therefore be mounted on a working field  $7 \times 9$  inches in size, if no reduction is desired. If reduction is desired, the size of the field may be  $9\frac{1}{2} \times 12$ ,  $10\frac{1}{2} \times 13\frac{1}{2}$ ,  $11\frac{1}{2} \times 15$ , or  $14 \times 18$  inches. Printed numerals and letters of standard size and form, to be mounted on the originals, may be obtained from the editors. In requesting them, please indicate the dimensions of the original plates before reduction.

All specimens except sections are to be photographed with the illumination incident from the upper left side, as is conventional. Line drawings of specimens need not show highlights, but if it is desired to show illumination, it is to be indicated as coming from the upper left side.

Maps, tables, groups of drawings of specimens, etc., that are to be used as text-figures will be either 3 inches or 7 inches wide, and  $8\frac{1}{2}$  inches in maximum length, after reduction. All drawings must be in ink, on opaque white stock. Lettering on maps, graphs, etc., should be of such a size that they will be not less than 2 mm. high after reduction.

An explanation must be furnished for every figure. Magnifications should correspond to the finished size of the plate or text-figure, not to the original size as submitted.

#### L'ENVOI

In the interests of maintaining the editors' health and peace of mind, and especially of keeping down printing costs, it is earnestly hoped that contributors will make a sincere effort to conform to the foregoing suggestions. Papers which are otherwise acceptable for publication in "Micropaleontology," but which depart seriously from the style requested, will be regretfully returned to their authors for retyping.

# news reports

## ARGENTINA



ESTEBAN BOLTOFSKY

In the present report, as well as in subsequent ones, I shall include an account of micropaleontological activities in the neighboring republic of Uruguay, in addition to those of Argentina. The following research work has been in progress in the Argentine since my last communication of August, 1955, and in Uruguay during the past several years.

### Foraminifera

Your correspondent has written a paper on the subject of chemical ecology as applied to the foraminifera. In this article, the very important role of so-called trace elements in all organic life is emphasized, and an attempt is made to explain some peculiarities of the Patagonian coastal foraminiferal fauna on the basis of the influence of these elements. It is the author's opinion that this type of investigation has great possibilities in micropaleontology. This paper appears in the present number of "Micropaleontology."

Another paper on irregularities in foraminiferal tests and their origin and significance will also appear soon. A large number of samples from the

northern part of the Argentine shelf, as well as data derived from the literature on this subject, were used as the basis of this study.

Your correspondent has also studied foraminifera encountered in samples collected from the Rio de La Plata. Some samples were preserved with formalin, which made it possible to determine which specimens were alive. These specimens belong to *Trochammina ochracea* (Williamson) and *Nonion tisburyensis* Butcher, which is rather interesting because the water in the area investigated is typically fresh.

Your correspondent is now working on the configuration of the Malvin current (Falkland Islands current), as indicated by foraminifera. The cold so-called Malvin current passes along the eastern border of the Argentine shelf, at some distance from the shore. It washes the vicinity of Tierra del Fuego and afterwards the region of the Malvin Islands, bringing with it the faunas typical of these regions, which are quite different from those of the western (coastal) part of the shelf. The study of the foraminifera has as its purpose the determination of the borders of this current and the limits of its northern extent.

### Thecamoebina

Your correspondent has also completed a study of eighty-two bottom samples collected in the Rio de La Plata between Puerto Nuevo of Buenos Aires and the mouth of the Parana Guazu River. Eleven forms were determined, of which *Diffugia pyri-formis* Perty and *Diffugia mitriformis* Wallich were the most common. This paper is now in press.

### Radiolaria

Dr. J. Frenguelli (L.E.M.I.T., La Plata) and Dr. H. A. Orlando, of the University of Bahía Blanca, have published a paper entitled "*Spermatogonia antique* Leud.-Fortm." (Univ. La Plata, Notas del Museo, vol. 18, Zool., no. 161, 1955). This paper is based on a study of plankton collected by the second author in the Argentine Antarctic. *Spermatogonia antique* consists of spicules of the radiolarian *Sticholonche zanglea* Hrtw.

### Infusoria

Dr. E. Balech of the Estación Oceanográfica del Puerto Quequén is engaged in a study of representatives of the marine planktonic group Tintinninea from the French Antarctic. The samples were sent to him by the University of Paris, Station Zoologique de Villefranche s/Mer.

Dr. R. A. Ringuelet of the Dirección de la Conservación de la Fauna, La Plata, has prepared a paper entitled "Nuevos foliiculinidos antárticos (Ciliata, Heterotricha)." In this paper, three species new to the Antarctic are described: *Parafolliculina amphora* Dons., *Parafolliculina violacea* (Giard), and *Parafolliculina patagonica* (Ring.). The fauna is compared with that of Patagonia. The material was collected in the Melchior Archipelago and from the Weddell Sea.

### Cladocera

Dr. Frenguelli has begun studies of Antarctic Cladocera from samples collected in the Argentine sector of the Antarctic. Dr. S. A. Olivier of the University of La Plata is still working on this group of organisms; he is now studying specimens that he collected from fresh waters in Tierra del Fuego during a visit there in 1954-1955.

#### Microscopic elements of larger animal skeletons

Dr. Ringuet has started a systematic study of extensive sponge-spicule material from the Pampeano (Quaternary) of the Province of Buenos Aires. This material consists of several hundred slides prepared and studied primarily for their diatom content by Frenguelli over a period of several years.

#### Diatoms

Dr. Frenguelli has been carrying on research on this group of microscopic plants for a period of thirty-three years. His study of diatoms from Antarctic samples collected by H. A. Orlando is now near completion. His investigation of the diatoms of Lake Chasico, in the southern part of Buenos Aires Province, is also nearly complete. This microflora consist of brackish-water species which are characteristic of the Upper Quaternary deposits of the Argentine.

At the same time, Dr. Frenguelli is studying fossil diatoms from the Eocene of Aguada del Guanaco in northern Patagonia. This work is especially interesting because the specimens are the first reported from the Eocene of the Argentine. The microflora encountered is poor; its predominant genera, *Coscinodiscus* and *Gomphonema*, are represented by several new species. They were found in lacustrine sediments that are analogous to the deposits described by C. Burckhardt in 1900, on the other side of the Andes at Arroyo Pedroso in Chile.

The study of diatoms from the plankton of the French Antarctic now being carried on by Dr. Frenguelli is most interesting. As we mentioned before, the samples were sent to Dr. Balech by the University of Paris. The microflora encountered is monotonous. The predominant genera are *Charcotia*, *Coscinodiscus*, *Arachnodiscus*, *Chaetoceros*, *Triceratium*, *Biddulphia*, and *Fragilaria*. A detailed study of this flora is in progress.

Mention should also be made of Dr. Frenguelli's study of diatoms in the Platense sediments, in collaboration

with Dr. S. Cortezzi (L.E.M.I.T., La Plata). These sediments are from the old, now almost extinct, lake of Cuanacache. The investigation is at present under way.

Our colleague from Uruguay, Dr. F. C. Müller-Melchers (Museo de Historia Natural, Montevideo), has also been very active in recent years in diatom studies. His first paper on diatoms (1945, Com. Bot. Mus. Hist. Nat. Montevideo, vol. 1, no. 17) dealt with the diatom flora of peat samples collected at various localities in Uruguay. Seventy-four forms, the majority of which were illustrated, were described. Later papers by this author were also published in the same journal (1952, vol. 2, no. 26; 1953, vol. 3, no. 30). He has also published papers in the Argentine journal "Physis" (1951, vol. 20, no. 58; 1953, vol. 20, no. 59), and in "Lilloa," published at Tucuman, Argentina (1949, vol. 19). In general, he has written on planktonic diatoms from the South Atlantic Ocean near the shores of Uruguay. Last year, Dr. Müller-Melchers was invited to the First Plankton Symposium in Latin America, organized by UNESCO in San Paulo (November, 1955), where he presented an interesting paper entitled "Diatomeas planctónicas como indicadores de corrientes y ambientes marinos." At present he is continuing his studies on the latter subject, as well as his long-term investigations of planktonic diatoms from Uruguay. He has also started the determination of diatom species in bottom samples collected near the shores of the Argentine province of Buenos Aires, and in surface samples collected near Cuba by Dr. Suarez-Caabro. Dr. Müller-Melchers has also begun to use the electron microscope in the study of diatoms.

#### Flagellata

Dr. Frenguelli is still working with this group of organisms. In material from the Argentine Antarctic, he has found a new species of the genus *Hemesinella* (Ebriaceae), which until now has been known only in the fossil state.

#### Plankton in general

Dr. Ringuet and Dr. Olivier have completed a paper entitled "Zooplankton de agua dulce de la República Argentina." This work consists of two parts and contains, in all, approximately 1200 pages and numerous figures. The first part presents a general description of the problems connected with the study of the plankton of continental waters. The second part is a synthesis and revision of the systematics of all known Argentine species. It contains brief descriptions of the species and a key for their identification. This work is the first of its type in all of Latin America, and we have no hesitation in saying that it will be very well received.

ESTEBAN BOLTOVSKOY

Museo Argentino de Ciencias Naturales  
Buenos Aires

#### AUSTRALIA



IRENE CRESPIN

The micropalaeontological laboratory of the Bureau of Mineral Resources at Canberra continues its investigations on large collections of material made by geologists of the Bureau during the 1955 field season and on material submitted by private companies engaged in the search for oil throughout Australia. Most of this material comes from Western Australia, where interesting stratigraphic sequences of Eocene, Upper and Lower Cretaceous, and Permian faunas are being found.



Many new genera and species of foraminifera are being discovered. Furthermore, rich ostracode assemblages are being found in the Lower Carboniferous and Devonian rocks of Western Australia, as well as wonderful assemblages of Upper Cretaceous Radiolaria.

The writer is slowly preparing a monograph on the Permian foraminifera of Australia, and D. J. Belford is preparing a publication on the Upper Cretaceous microfaunas. Two new micropalaeontologists have joined the Bureau staff: P. W. Jones comes from the University of Manchester, and G. Jenkins, a student of Professor Alan Wood of Wales, is studying some of the Tertiary foraminifera for his doctorate.

Dr. M. F. Glaessner returned from overseas in April after attending the World Petroleum Congress in Rome and visiting many micropalaeontological laboratories in Europe. Dr. Felix Kicinski, who is with the Australasian Petroleum Company in Papua, has spent some time in the field in western Papua but is now back in the laboratory at Port Moresby. Alan Carter is continuing his work on Victorian Tertiary foraminifera. B. E. Baulme of the Coal Research Division, Council of Scientific and Industrial Research Organization, has shown some interesting results of his work on spores from deep bores in Western Australia.

Professor J. J. Graham of California, who for some time has been organizing a micropalaeontological laboratory at the University of the Philippines, recently paid a hurried visit to Australia and New Zealand. He was accompanied by Dr. F. Gutierrez, who will take charge of the laboratory. Several days were spent in the laboratory at Canberra, and short visits were made to South Australia, Victoria and Tasmania to collect Tertiary material.

Professor Kenneth Caster of the University of Cincinnati is at present in Australia on a Fulbright scholarship. After studying the Devonian faunas in Tasmania, he made a short visit to Canberra to study the collections there, and will later go to the Kimberleys in Western Australia.

M. A. Condon, Assistant Chief Geologist of the Sedimentary Section, Bureau of Mineral Resources, and Dr. A. A. Öpik, the well-known authority on Cambrian faunas, will represent the Bureau at the forthcoming International Geological Congress at Mexico City.

IRENE CRESPI  
Bureau of Mineral Resources  
Canberra

## BENELUX



J. H. VAN VOORTHUYSEN

### BELGIUM

University of Louvain, Coal Museum

Dom Remacle Rome, O.S.B., Director of the Paleontological Museum of the University of Louvain, has nearly completed his study of the ostracodes of the basal Tournaisian (Carboniferous) in collaboration with Abbé J. Goreux.

University of Louvain, Geological Institute

This year Dr. F. Gullentops published a study of the foraminifera of the fluvio-marine Tongrian (Lower Oligocene) of Belgium. During the next few months he will be working on a detailed study of the Lagenidae of the Neogene, which he intends to compare with the Recent lagenid fauna of the North Sea.

University of Liege,  
Laboratory of Micropaleontology

Professor Ubachs is engaged in a study of Neogene microfaunas from the Cuanza sedimentary basin of An-

gola. Mr. Meyer has been working on Upper and Lower Cretaceous formations of the same basin. He has encountered several horizons characterized by rich pelagic associations, including species of *Schackoina*.

Royal Belgian Institute of Natural Sciences,  
Botanical Section, Brussels

This year Dr. Vanhoorne will publish a study of one of the few undamaged peat layers in the Belgian Ardennes of late Atlantic age, the "Fange aux Mochettes." The paper will appear in the *Mededelingen van het Koninklijk Belgisch Instituut voor Natuurwetenschappen*, volume 32, number 30. In addition, Dr. Vanhoorne is at work on an extensive study of the Pleistocene flora of Belgium; he hopes to have it ready for publication within the next year.

### NETHERLANDS

University of Leiden

Professor van der Vlerk, together with Dr. T. F. Grimsdale, is engaged in a revision of the family Lepidocyclinidae. Under Professor van der Vlerk's supervision, A. J. Wissink is working on a study of heterosteginids from Angola. This work will be published in the near future in the *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen*.

Professor F. Florschütz, Director of the Paleobotanical Laboratory at the University of Leiden, is continuing to train students in palynology. One of his students has studied peat and gyttja samples from Italy for his doctor's degree. As Director of the Paleobotanical Laboratory of the Government Agricultural Experiment Station at Velp, Gelderland Province, Professor Florschütz is also continuing his palynological studies of Pleistocene and Holocene bottom samples. A few series of samples of Pliocene and Miocene age have also been studied, as well as material from France and Spain.

University of Utrecht

Dr. C. W. Drooger, Conservator of the Geological Institute, published two



papers during the past year. The first, entitled "Remarks on *Cycloclypeus*" (1955, K. Nederl. Akad. Wetensch., Proc., ser. B, vol. 58, no. 5), was a statistical study. Drooger was unable to recognize the elementary species of Tan Sin Hok. In the other paper, "Miogypsina at Puente Viejo, Spain" (1956, *ibid.*, ser. B, vol. 59, no. 1), Drooger contradicts earlier statements concerning nepionic retardation in the Miogypsina of Puente Viejo. He is now working on the correlation of the Helvetian and Tortonian (Middle and Upper Miocene).

Dr. F. P. Jonker, Conservator of the Botanical Museum and Herbarium, informs me that some of his students are making a pollen-analytical study of Holocene peats in Friesland Province and in the Cretaceous district of the southern part of Limburg Province. Dr. Jonker and his wife, Mrs. A. M. E. Jonker-Verhoef, visited the coastal region of Surinam from November, 1955, until March, 1956. They collected many peat samples and began a palynological study of the peat of Surinam. It was found that peat formation in Surinam is on a minor scale only. In addition, Dr. Jonker studied the flora around the swamps, in order to compare the Recent pollen with that of the peat. In collaboration with the Government Agricultural Experiment Station at Paramaribo, Dr. Jonker collected a series of peat samples from the Nickerie district, in the western part of Surinam, relating to the archaeological discoveries made there.

#### University of Amsterdam

In the Department of Paleontology, of which Professor H. J. MacGillavry is Director, a special study has been made of the evolution of larger foraminifera. *Lepidorbitoides* material from St. Marcet (*Lepidorbitoides socialis*) and from Maastricht and Germany (*Lepidorbitoides minor*) has been examined. Biometric studies show that these two species had an independent origin and an independent evolution. Each shows an evolutionary increase in the number of adauxiliary chambers, but the range and rate of this change

differ for the two species. A paper on this subject by Professor MacGillavry, entitled "Two evolving species of the genus *Lepidorbitoides* Silvestri, a biometrical study," will appear shortly in the Mededeelingen van de Geologische Stichting. A study of the Maastricht material is being made as part of the revision program of the Maastrichtian type section now being carried on by the joint action of the members of a special committee. A special collecting trip has been made to Klein St. Paul, to visit the localities from which Mr. Papp, of Vienna, described his *Lepidorbitoides* material. Mr. Papp and the author will collaborate on some of the fossils found there. The more theoretical aspects of evolution are treated in a paper by Professor MacGillavry, entitled "Mutation pressure a possible cause of directional evolution in *Cycloclypeus* Carpenter (Foraminifera)," which will appear toward the end of the year.

Some of Professor MacGillavry's students are studying *Globotruncana* material from southern France and from Corsica. Others are studying smaller foraminifera and Ostracoda from the Cretaceous of Maastricht.

Professor J. H. Heimans, Director of the Hugo de Vries Laboratory, Hortus Botanicus, informs me that his students are engaged in palynological studies of Holocene and Pleistocene peat layers in different regions of the Netherlands. Special studies relate to peat at greater depths in the subsurface of Amsterdam (early Holocene), and tumuli from the Bronze Age in the province of North Holland.

#### Geological Bureau of the Netherlands Coal Mining District

Dr. S. Dijkstra has published three papers: "The megaspores of the Westphalian D and C" (1955, Netherlands, Geol. Stichting, Meded., new ser., no. 8, pp. 5-11, pl. 2); "La corrélation des veines de charbon par les mégaspores" (1955, Assoc. Étud. Pal., Publ., no. 21, pp. 107-119, pl. 1); and "Megaspores carboníferas españolas y su empleo en la correlación estratigráfica" (1955, Estud. Geol.,

vol. 11, no. 27-28, pp. 277-354, pl. 11). He also has a paper in press, entitled "Some Brazilian megaspores, Lower Permian in age, and their comparison with Lower Gondwana megaspores from India" (1956, Netherlands, Geol. Stichting, Meded., new ser., no. 9).

#### Geological Survey of the Netherlands

W. H. Zagwijn is in charge of the Palaeobotanical Laboratory. Studies on the paleobotany of the Dutch Lower Pleistocene and Pliocene have been continued this year. As a result of this work, the stratigraphy of these periods, based on vegetational changes which are clearly caused by climatic alterations, has been established. The results will be published next year.

Much additional work has been done on the pollen analysis of the Holocene in the Dutch coastal areas, partly in connection with radiocarbon datings, partly also in connection with new geologic mapping of the Netherlands by the Geological Survey. Also in connection with radiocarbon datings, a new investigation has been started on the type locality of the Eemian (Last Interglacial) stage.

We now have on our staff A. van der Werff, the diatom specialist, who has been with us since the beginning of this year. He is working on ecologic problems in the Holocene. Good progress has been made on the ecologic and sedimentary study of the Eems estuary (Wadden Sea). It is hoped that the results can be published within two years.

D. A. J. Batjes is now assisting us in the study of the Tertiary stratigraphy of the Peel region, a future coal-mining district. Mr. Batjes hopes to have his dissertation, on the foraminifera of the Belgian Oligocene, completed in the autumn of this year.

Your correspondent has recently published a paper, entitled "Some notes on the microlithology of the siderite and illite facies occurring in the sediments of the North Sea Basin" (1956, Geol. en Mijnb., new ser., vol. 18, no. 5, pp. 166-170). During 1955 and

1956, the following persons visited us in Haarlem: A. F. J. Smit of the University of Achimota, Gold Coast, Africa; Professor F. van Rummelen of Bogor, Indonesia; Dr. V. Grekoff of Paris; W. P. Popenoe of the Department of Geology, University of California at Los Angeles; and Professor Seibold and his wife, from Tübingen, Germany.

**The laboratory of Dr. Jan Hofker, The Hague**

By the time this account is published, it is expected that several larger papers will have been issued. They are: "Foraminifera of the Eocene of Ecuador" (Jour. Pal.); "The foraminifera of the West Indies" (Spolia Zoologica, Copenhagen); "The foraminifera of the *Pseudotextularia* zone" (Pal. Zeitschr.); "The foraminifera of the Hervian" (Netherlands, Geol. Stichting, Meded.); and "Die Globotruncanen von Nord-West Deutschland und Holland" (Jahrb. Geol. Pal.). In the meantime, several papers on the foraminifera of the Maestrichtian chalk have been published as parts of the series "Foraminifera from the Cretaceous of Southern Limburg, Netherlands." They include notes on species of *Bolivinoidea*, on *Bolivina firma* Hofker, on *Globorotalia mosae* Hofker, on *Nonionella cretacea* (Reuss), on the genus *Allomorphina*, on *Dictyoconus mosae* Hofker, on *Eponides involuta* Hofker, on *Rotalia trochidiformis* (Lamarck), on *Gavelinella umbilicatiformis* Hofker, and on *Cibicides bosqueti* (Reuss), all of which were published in volume 44 (1955) of the *Natuurhistorische Maandblad*, Maastricht. Further papers in the same series, on the genus *Orbignyana*, on *Dictyopsella tenuissima* (Reuss), on *Bolivinoidea polonica* Pozaryska, on *Lagena acuticosta* Reuss, and on *Eponides toulmini* (Brotzen), were published in volume 45 (1956) of the same journal. Also in the same series, a longer paper is in press on the planktonic foraminifera of the tuff chalk of Maastricht, showing that nearly all these beds are of Danian-Paleocene age. Many more papers, mainly on the development of various species in the tuff chalk of Maastricht, have been planned.

Larger papers on the foraminiferal faunas of the Craie de Nouvelles, Craie de Spiennes, Craie phosphatée de Ciply, the Tuffeau de Saint Symphorien, and the Tuffeau de Ciply, and a paper on the development of the genera *Bolivinoidea* and *Neofabelina* during the uppermost Cretaceous, are ready for the press, as well as papers dealing with the foraminifera of the lowermost Paleocene of the Netherlands, and of the upper and lower Md, the Mc and the Mb. A study of the Cretaceous of northeastern Belgium is now in progress, and several parts of a larger paper on this region are already finished, as well as a paper on the evolution of pore diameters in the Gavelinellidae of northern and southern Belgium, the Netherlands, and northwestern Germany.

Study of the so-called Cretaceous of several mine shafts in Dutch Limburg has revealed that earlier authors have erred in their determination of these beds. Only erosional remnants of the tuff chalk are found here, all of lowest Md age, and thick beds of quite different age occupy the position of the tuff chalk here. To resolve these questions, a large series of samples spaced 50 cm. apart was taken in a newly made shaft of the Maurits mine. Here the limnic upper Montian, the typical tropical Montian, the Tuffeau de Ciply, and the Lower Paleocene overlie in clearly deposited sediments the remnants of the lower Md, which, at its base, lies upon the Hervian Cretaceous. A full description of the foraminifera of this mine shaft is in preparation.

A smaller paper, dealing with the inner structures of *Globotruncana*, *Globorotalia*, and *Rugoglobigerina*, is published in the present number of "Micropaleontology." Many other studies on the inner structures and taxonomy of the foraminifera are in progress or already finished. They deal with *Colomia*, *Plummerinella*, and *Pseudoeponides*.

In connection with the study of the Upper Cretaceous of northeastern Belgium mentioned above, the so-called

Gulpen chalk of South Limburg, Netherlands, will also be analyzed, and its foraminiferal faunas will be described. The lower boundary of the Maestrichtian can be seen in this Gulpen chalk.

J. H. VAN VOORTHUYSEN  
Netherlands Geological Survey  
Haarlem, Netherlands

**ISRAEL**



Z. REISS

In September, 1955, your correspondent left Israel for a six-month study trip to Europe under a UN-TAA Economic Development Fellowship grant. Before his return to Israel in March, 1956, he visited various micropaleontological laboratories in France, Switzerland and England, where he studied a wide range of micropaleontological problems with special reference to applied micropaleontology in petroleum research. During his stay in France, he also made several field trips.

Since returning to Israel, your correspondent has continued work on the stratigraphy of the Jurassic and Lower Cretaceous of this country, on the basis of both microfaunas and microfossils, as well as on various other research projects. Special attention is being paid at present to microorganisms other than foraminifera, such as ostracodes, ophiuran remains, and algae. The systematic investigation of foraminiferal species from various formations of the country continues, and at present the pelagic genera are under revision.

Short notes on two new genera of foraminifera and on the differences between *Truncorotalia aragonensis caucasica* (Glaessner) and *Truncorotalia velascoensis* (Cushman) have been submitted for publication in the Bulletin of the Research Council of Israel. Several other papers are in preparation. Routine work in connection with petroleum research and with the search for ground water and mineral deposits, as well as in connection with the geologic mapping of the country, continues at the Laboratory of the Geological Survey of Israel, on a fairly large scale. A micropaleontological reference book, containing almost 2000 drawings of foraminifera, distribution charts, etc., has been prepared by your correspondent and one of his assistants, and has been distributed to oil companies for their geologists and well-sitters. A short course in practical micropaleontology for oil-company geologists has been started by your correspondent at the Geological Survey of Israel.

Z. REISS

Laboratory of Micropaleontology  
Geological Survey of Israel  
Jerusalem

## NEW ZEALAND



N. DE B. HORNIBROOK

During this year, The Shell d'Arcy Todd Group has been carrying on oil exploratory work in North Island in areas of Cretaceous and Tertiary rocks. Micropaleontological activity in New

Zealand will increase greatly within the next few years if Shell and British Petroleum bring in their own men.

Paul Vella, who left the Geological Survey in 1954 to take up sheep farming, is acting as micropaleontologist to Todd Brothers and is working with Upper Cretaceous to Miocene foraminifera. His paper on the foraminifera of Cook Strait and the genus *Notorotalia* will appear within the next few months as Palaeontological Bulletin 28 of the New Zealand Geological Survey.

Dr. J. T. Kingma of the New Zealand Geological Survey has been transferred to Wellington and is going to take up micropaleontology again. He will concentrate on Miocene to Pleistocene foraminifera. R. A. Couper is still at Cambridge working on Mesozoic spores, but we expect him back in New Zealand at the end of this year. In May of this year we were very pleased to have visits from Professor Joseph Graham of Stanford University and Professor Fernando Gutierrez of the University of the Philippines.

At Canterbury University College, George Scott is studying the succession of foraminifera in sections along the Otaio River in South Canterbury from a paleoecological standpoint. This is the type area of the Otaian stage.

Your correspondent, although occupied with varied problems of correlation, has been working away steadily on the Eocene and Oligocene foraminifera of the Oamaru district (South Island), where some of our richest microfaunas occur. The illustration of about 300 species by pen-and-ink drawings was a rather alarming project but has now been completed.

N. DE B. HORNIBROOK

Geological Survey of New Zealand  
Wellington

## PERU



EDWIN T. ASHWORTH

### Empresa Petrolera Fiscal

A. Euribe is at Stanford University in California on a Point Four scholarship. He is expected back in Peru in September. J. Cruzado recently assumed responsibility for the paleontological laboratory at Zorritos, but resigned in May to return to Lima, where he will present his thesis at the University of San Marcos. His thesis deals with the stratigraphy of the Punta Bravo-Carpitas area in northwestern Peru, based on a study of the microfaunas of the region. F. Seminario, a graduate of the University of San Marcos, has been appointed assistant in the Zorritos laboratory. He is occupied mainly with routine well work.

### Compañía Petrolera Lobitos

R. Phillips is in charge of paleontological activities, and reports that he is engaged chiefly in routine well work. He adds, however, that he is working up a series of panel maps showing the changes in lithologic facies of the Eocene beds, with the ultimate idea of working out the paleogeography of the El Alto area. He is being assisted in well-sample work on a part-time basis by Mrs. A. J. Knights, the wife of the chief geologist of this company.

### International Petroleum Company, Ltd.

Lawrence Weiss, your former correspondent, has transferred to the Carter Oil Company at Billings, Montana, where he is working with Dr. R. M. Stainforth, another former Talara

paleontologist. Several excellent papers by these two men have recently been published. They include "Ages of Tertiary formations in northwest Peru," by Stainforth (1955, Amer. Assoc. Petr. Geol., Bull., vol. 39, pp. 2068-2077); and "Foraminifera from the Paleocene Pale Greda formation of Peru" (1955, Jour. Pal., vol. 29, no. 1, pp. 1-21) and "Planktonic index foraminifera of northwestern Peru" (1955, Micropaleontology, vol. 1, pp. 301-319), both by Weiss.

Your correspondent is in charge of the Talara laboratory. In addition to well-correlation problems, he is collaborating with Benton Stone, of the Standard Vacuum Company, Sumatra, on a paper describing the foraminifera of the Talara formation (Middle to Upper Eocene) of northwestern Peru. He is also presenting a short note on the presence of *Globotruncana ventricosa* in Peru.

Fernando Zuñiga has joined the paleontological staff in Talara. He formerly worked as a well geologist in Talara, and later with Exploration Operations in Lima, before going to the United States on an International Petroleum Company scholarship. He studied at the University of California at Los Angeles for a year.

Dr. A. G. Fischer, of Exploration Operations in Lima, is leaving the company to join the faculty of Princeton University, where he will teach invertebrate paleontology.

EDWIN T. ASHWORTH  
International Petroleum Company, Ltd.  
Talara

## PORTUGAL OVERSEAS



ARMENIO T. ROCHA

### Missão de Biologia Marítima do Ultramar

Pursuing the study of the marine plankton of Angola, Portuguese West Africa, this Mission carried on horizontal collecting, during both the day and the night, in Farta Bay, near Benguela, between June and November, 1955. The samples collected by former expeditions have, for the most part, been studied, and the results have been published or are in the course of publication. The topics covered so far include: "Copépodes marinhos de Angola," by Emérita Marques; "Radiolários marinhos do plancton de Angola," by J. Santos Pinto; and "Diatomáceas marinhas de Angola," "Red water" por *Exuviella baltica*, "Dinoflagelados do plancton marinho de Angola," and "Tintinnóinea do plancton marinho de Angola," all by Estela de Sousa e Silva. These papers have appeared or will appear in "Trabalhos da Missão de Biologia Marítima," nos. 3 to 6 and subsequent numbers. Another paper by Estela de Sousa e Silva, entitled "Contribuição para o estudo do micro-plancton marinho de Moçambique" (Portuguese East Africa), has also been submitted for publication. The expedition proposed for the current year will make new collections in southern Angola, from Lobito to the mouth of the Rio Cunene (lat. 12°15' to 17°20' S.). Inquiries regarding these studies should be addressed to Dr. H. Vilela, Chief of the Missão de Biologia Marítima do Ultramar, Largo do Figueiredo 1, r/c Esq., Lisbon.

### Missão de Pesquisas de Petróleo - Purfina

H. Hoppener reports the following activity. The Missão de Pesquisas de

Petróleo of Purfina C.C.L., a subsidiary company of the Compagnie Financière Belge des Pétroles (Petrofina), has been exploring for oil in Angola since 1952. From 1952 to about 1954, micropaleontological investigations of samples were carried out by Mrs. E. Cuvillier (Mrs. E. Tachet des Combes) in France and in Belgium. In 1954, micropaleontological activity in the Luanda office in Angola began, with the arrival of H. Hoppener.

Applied micropaleontology is dealt with in Luanda, including routine examinations of the samples, biostratigraphic subdivision of well sections, establishing formational contacts by means of fossils, and paleontological correlation. Scientific micropaleontology is carried out at the University of Liège in Belgium. There, Professor G. Ubachs and M. M. J. Meyer make specific determinations of foraminifera, provide information concerning the age of the formations, and keep a card index of the fossils, with photographs and descriptions.

Because Angola is one of the virgin areas in the world, as far as micropaleontology is concerned, the Luanda laboratory had to start from the very beginning and set up a type collection of microfossils. In the course of one year, between October, 1954, and December, 1955, a total of about 16,800 sample residues were examined under the stereomicroscope. About 75% of these samples came from the Benfica no. 1, no. 2, and no. 3 wells. The other 25% were from shallow seismic drill holes in the Luanda area and from outcrops. About 26,640 foraminifera, picked from samples ranging in age from Senonian to Miocene, were mounted in reference slides. A large number of these foraminifera or foraminiferal associations, as well as Radiolaria, Mollusca, Echinoidea, fish otoliths, and oolites, have been found useful for correlation purposes.

### Serviços Geológicos de Portugal

In the "Comunicações dos Serviços Geológicos de Portugal" (vol. 24, 1954), Miss Atife Daci, of the Geological Institute of Istanbul Univer-



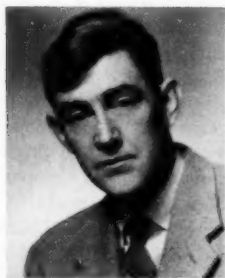
sity, reports that she has found that the Miocene operculines of Angola constitute a single species, which certainly belongs to the group of *Operculina complanata*. She describes it as a new species, *Operculina benevidea*.

**XXIII Congresso Luso-Espanhol para o Progresso das Ciências**

At this Congress, which was held at Coimbra in 1956, the following papers on micropaleontology were presented: "Ocorrência de foraminíferos planctônicos no Terciário de Luanda," by J. Martins Ferreira; "Sobre a posição estratigráfica dum nível com foraminíferos no Cretácico de Catumbela (Angola)," by J. Martins Ferreira and A. Tavares Rocha; "Foraminíferos planctônicos de Catumbela," by A. Tavares Rocha; and "Foraminíferos do Terciário superior de S. Pedro da Barra (Angola)," by A. Tavares Rocha and J. Martins Ferreira.

ARMÉNIO TAVARES ROCHA  
Lisbon

**UNITED STATES—  
ROCKY MOUNTAIN REGION**



R. M. STAINFORTH

Readers will notice a change in the geographic division of the United States for the purposes of regional news reports. From the geologic point of view, the Rocky Mountain province is more homogeneous than the former "North-Central States" province. The area now reported on includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming.

Enquiries have revealed only a limited program of micropaleontological studies in progress, which is surprising in view of the great size of the area and the unceasing research into other aspects of Rocky Mountain geology. A possible explanation is that several of the eastern universities use the Rockies as a training ground for geology students, and thus there may be important research under way which has not come to your correspondent's attention. Any information on such projects, as well as reprints of published papers, would be gratefully received for mention in future news reports.

**Arizona**

No reports of activity received.

**Colorado**

W. A. Cobban reports no micropaleontological activity at the United States Geological Survey in Denver. L. W. LeRoy, of the Colorado School of Mines, states that no one there is working on foraminifera except for his own part-time studies of material from Okinawa. J. Harlan Johnson is continuing to study the coralline algae, which, although not strictly microfossils, are studied under the microscope. In recent papers he has summarized the ancestry of the group and described a new Pennsylvanian genus, *Archaeophyllum* (1956, Jour. Pal., vol. 30, no. 1, pp. 53-55; no. 3, pp. 563-567).

The oil companies make some use of micropaleontology in their stratigraphic studies. J. F. Clement, for instance, is working on Cretaceous foraminifera in the Denver office of the Carter Oil Company.

**Idaho**

Pennsylvanian and Permian fusulinid faunas from the Wood River formation in the vicinity of its type section were recently described by D. A. Bostwick (1955, Jour. Pal., vol. 29, no. 6, pp. 941-951). Walter Youngquist and Jerald R. Haegele listed similar assemblages from the Sublett Range (1955, Amer. Assoc. Petr. Geol., Bull., vol. 39, no. 10, pp. 2078-2080; also 1956, *ibid.*, vol. 40, pp. 1716-1722).

**Montana**

There seem to be no academic studies in progress. The Carter Oil Company maintains a small laboratory in Billings, where R. M. Stainforth is applying microfossils to stratigraphic problems. Lawrence Weiss is leaving Billings and will return to Talara, Peru.

**Nevada**

Joseph Lintz reports from the Mackay School of Mines at Reno that he knows of no research being conducted within the state, although graduate students from the California universities may possibly be working on material collected at their summer field camps in Nevada.

Lower Permian fusulinids were identified by M. L. Thompson in connection with dating a *Helicoprion* found in Nevada (1955, Jour. Pal., vol. 29, no. 6, p. 919). Fusulinids were also applied in the zonal subdivision of the Pennsylvanian of Nevada, in a paper by R. H. Dott, Jr., which won the A.A.P.G. President's Award for 1955 (1955, Amer. Assoc. Petr. Geol., Bull., vol. 39, p. 2219). Micropaleontological techniques were applied by R. H. Waite in his study of small Silurian brachiopods from Nevada and Utah (1956, Jour. Pal., vol. 30, pp. 15-18).

**New Mexico**

Christina Lochman Balk states that no studies of micropaleontological character are in progress at the Institute of Mining and Technology, Socorro, although M. L. Thompson, of the University of Kansas, is analyzing some late Paleozoic fusulinid faunas from New Mexico. Rousseau H. Flower of the Institute has joined issue with Weller's recent criticism of the utility of a formally recognized kingdom of Protista intermediate between the plant and animal kingdoms. He succinctly expresses the view that, firstly, the borderline protistid kingdom exists, and, secondly, the difficulty of fitting the Protista into a compartmentalized dichotomous classification is no reason for suppressing this kingdom but, on the contrary, deserves stressing



as a reminder of the unified origin of all organic life (1956, Jour. Pal., vol. 30, pp. 700-706).

In recent years the technique of freeing siliceous fossils from massive limestones by digestion in acid has revealed many new faunas. A further example is an assemblage of tiny but distinctive brachiopods described by G. Arthur Cooper from the Pennsylvanian Magdalena formation in the Sacramento Mountains (1956, Jour. Pal., vol. 30, pp. 521-530).

#### Utah

The University of Utah at Salt Lake City provides an exception to the generally negative tone of this report, and Daniel J. Jones reports two thesis studies in progress. One is by Fred R. Griesbach, on spores and pollen in coals of the Frontier formation (Upper Cretaceous). The other is by Harold R. Donaldson, on the microfauna of the Tropic formation (Upper Cretaceous), in particular at the Coal Creek section, where zones of marine foraminifera alternate with zones of non-marine ostracodes and charophytes. Professor Jones is himself engaged in three projects on nonmarine microfaunas, namely: (1) zonal analysis of the prolific ostracode faunas of Pleistocene Lake Bonneville; (2) relation of ostracode and charophyte zones to the established vertebrate horizons of the Uinta Basin Tertiaries; this project is supported by a G.S.A. grant and will be extended to the Eocene of the Bridger Basin; (3) the bizarre ostracode fauna of the Idaho formation of southern Idaho (in conjunction with Norman R. Anderson). A course in stratigraphic micropaleontology has been added to the University's curriculum this year.

The Seventh Annual Field Conference of the Intermountain Association of Petroleum Geologists was held in east-

central Utah. The guidebook for this meeting included two papers of micropaleontologic interest: "Early Tertiary ostracode zones of the Uinta Basin," by F. M. Swain, and "Charophytes as a guide to distinguishing between Lower Cretaceous and Upper Jurassic continental sediments in the subsurface," by J. G. Mitchell. The editor of this guidebook was J. A. Peterson of the Shell Oil Company, well known for his papers on Mesozoic ostracodes.

J. Stewart Williams reports that there is no micropaleontological activity at the State Agricultural College at Logan.

M. L. Thompson and Doris N. Zeller have recorded a significant Pennsylvanian (Derryan) microfauna in Utah. It is characterized by *Profusulinella regia* and follows a Morrowan(?) assemblage of *Staffella* and *Millerella* (1956, Jour. Pal., vol. 30, pp. 333-337).

The news from Utah would not be complete without mentioning the new addition to Harper's Geoscience Series of textbooks, "Introduction to microfossils," by Daniel J. Jones. The few other books in this field—even Glaessner's "Principles of Micropaleontology"—emphasize the foraminifera so heavily that this new text with balanced coverage of all microfossils is assured of a hearty welcome.

#### Wyoming

The Shell Oil Company's micropaleontology laboratory located at Casper is now in the fifth year of operation. Work is concentrated on the Mesozoic of the Rocky Mountains and Great Plains. R. L. Heacock is in charge of this work and is assisted by Miss E. E. Dobbins and Miss M. N. Gilman.

R. M. STAINFORTH  
Carter Oil Company  
Billings, Montana

## VENEZUELA



BOGUSŁAW J. SZENK

This is the first news report by your new correspondent, who replaces Dr. J. G. Bursch of the Phillips Petroleum Company, the correspondent for Venezuela during the period from 1953 to 1955. During the period covered by the present news report, most of the geological and paleontological work in Venezuela consisted primarily of studies concerning new oil concessions. These activities prevented many economic paleontologists from engaging in more scientific work.

#### Creole Petroleum Corporation

There are four paleontologists working at present at Creole's laboratory in Jusepín. They are Dr. P. J. Bermudez, A. N. Dusenbury, Jr., G. M. Sowers, and J. A. Sulek. Dr. Bermudez is now engaged in a study of pelagic foraminifera from the Caribbean-Antillean region. This work is being done in collaboration with Dr. Paul Bronnimann of the Cuban Gulf Oil Company. The illustrations will be made by Jorge Fournier of the Mene Grande Oil Company, who recently published a paper on "New methods and techniques in the photography of microfossils" (1956, Micropaleontology, vol. 2, no. 1). A revision of the Globigerinidae and Globorotaliidae from the Paleocene to the Recent of the Antil-

lean region, the southern part of the United States, and northern South America will be included. This work, which is about half completed, will be issued as a Special Publication of the Cushman Foundation for Foraminiferal Research. Dr. Bermudez has also completed a paper on Recent foraminifera from the Los Roques Islands of northern Venezuela, which is to be published in the "Memorias de la Sociedad de Ciencias Naturales de La Salle en Caracas."

Harry W. Anisgard of Creole's Maracaibo laboratory read a paper entitled "*Eorupertia* in the Eocene of Venezuela" at the Sixth Annual Convention of the Venezuelan Association for the Advancement of Science. It was published in the Contributions from the Cushman Foundation for Foraminiferal Research (1956, vol. 7, pt. 2). Mr. Anisgard also collaborated with others on a paper entitled "Habitat of oil in the Maracaibo Basin, Venezuela," which was presented at the Fortieth Annual Meeting of the American Association of Petroleum Geologists, held at New York, March 28-31, 1955, and which is now in press.

Dr. Virgil Winkler is continuing to act as coordinator between Creole's central offices in Caracas and the laboratories in Jusepín and Maracaibo.

#### **Compañía Shell de Venezuela**

Dr. Ewald T. N. Spiker, formerly in Maracaibo, has been transferred temporarily to Caracas. After attending the International Geological Congress in Mexico, Dr. Spiker will move to Trinidad to work for Shell Trinidad Ltd. Dr. Spiker's position in Maracaibo has been taken over by Andries Oosterbaan, formerly of Caracas. Dr.

Spiker's replacement in Caracas has not yet been announced. Bertram van Raadshoven has been transferred from Shell's Maracaibo laboratory to Houston, Texas.

#### **Mene Grande Oil Company**

Your present correspondent joined the staff of Mene Grande's stratigraphic laboratory in June, 1955. He is a graduate (class of 1951) of the Institute of Technology of Stuttgart, Western Germany.

Dr. H. H. Renz recently visited the Gulf Oil laboratory in Cuba, where he discussed the occurrences of fossils *incertae sedis* (*Nannoconus*) with Dr. Paul Bronnimann of the Cuban Gulf Oil Company. Dr. Bronnimann has been investigating these fossils. Dr. Renz is presently checking various Venezuelan sediments for the possible presence of *Nannoconus* and *Discoaster* and has found numerous specimens of *Discoaster* in Cretaceous and Eocene calcareous shales. In 1955, Dr. Renz published a paper entitled "Some Upper Cretaceous and Lower Tertiary foraminifera from Aragua and Guárico, Venezuela" (Micropaleontology, vol. 1, no. 1). He now has several papers in press. One, entitled "Stratigraphy and geological history of eastern Venezuela," will appear in the *Geologische Rundschau, Südamerika-Heft*. The other two, written in collaboration with numerous others, are: "The Eastern Venezuelan Basin," which was presented at the Fortieth Annual Meeting of the American Association of Petroleum Geologists; and "Geología de las cuencas sedimentarias de Venezuela y sus campos petrolíferos," prepared for the Nineteenth International Geological Congress, to be held at Mexico City in September, 1956.

#### **Socony Mobil Oil Company de Venezuela**

Donald O. Nelson, paleontologist at Socony's Anaco laboratory, was recently transferred to the Libyan Branch of Mobil Oil of Canada, Ltd., and is now located in Tripoli, Libya (P. O. Box 690). Foster D. Smith, Jr., was welcomed back to Anaco after a year and a half of absence. During this period, Mr. Smith was engaged in postgraduate studies at New York University.

#### **Venezuelan Atlantic Refining Company**

Dr. Wolf Maync recently resigned his position as Chief Paleontologist with the geological laboratory of this company and left for Switzerland, where he intends to spend three months on vacation. He has accepted a position as Consultant to the Exploration Department of the Compagnie d'Exploration Pétrolière, previously called the Société Nationale des Pétroles du Languedoc Méditerranéen. Dr. Frans Keijzer will take over Dr. Maync's position in Caracas.

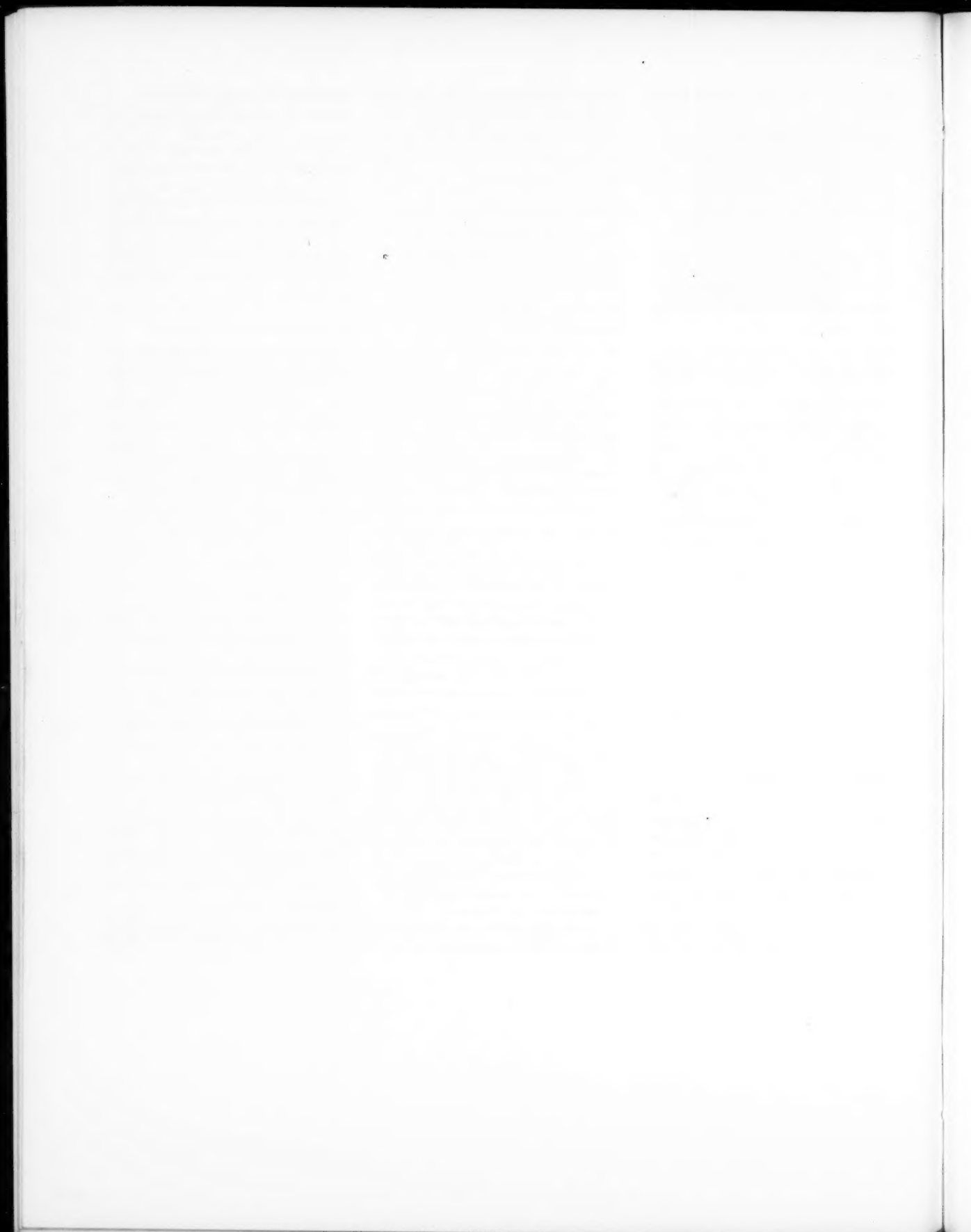
#### **Richmond Exploration Company**

William Weaver, paleontologist with the Richmond Exploration Company, has accepted a similar position with Esso Standard Oil, S.A., in Cuba. Mr. Weaver spent two years with Richmond in Venezuela. Robert Juroška, who is a micropaleontologist, recently joined Richmond's geological staff in Maracaibo.

#### **Sinclair Oil and Refining Company**

William MacFarquhar, a paleontologist who was formerly with Mene Grande in the stratigraphic laboratory, has joined Sinclair's geological staff at the Santa Bárbara camp in eastern Venezuela.

BOCULAW J. SZENK  
Mene Grande Oil Company  
Caracas



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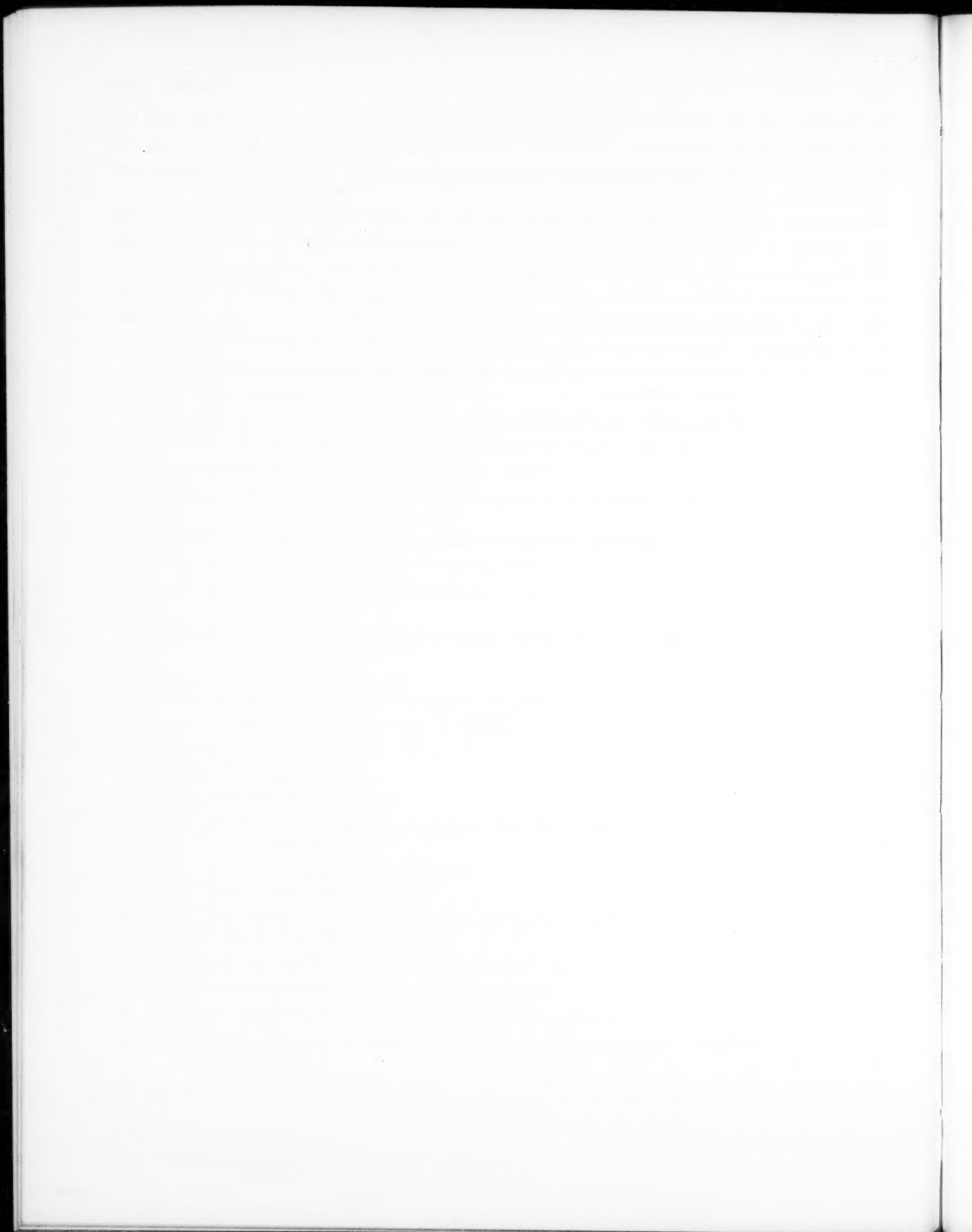
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The following list of correspondents is presented for the benefit of those who wish to submit news items for publication in this quarterly. Contributors should send such news items to the correspondents reporting for their own areas. Manuscripts of papers submitted for publication should *not* be sent to correspondents. They should be directed to: Department of Micropaleontology, American Museum of Natural History, Central Park West at 79th Street, New York 24, N. Y.

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